

Freshwater and Estuarine Fish and Fish Habitat Technical Data Report

LNG Canada Export Terminal

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LNG CANADA
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EXECUTIVE SUMMARY

LNG Canada Development Inc. (LNG Canada) is proposing to construct and operate a liquefied natural gas (LNG) facility (including an LNG processing and storage site and marine terminal) in the District of Kitimat, British Columbia (BC), and to export LNG from the facility by shipping. This proposed project is called the LNG Canada Export Terminal (the Project).

This technical data report (TDR) describes the freshwater and estuarine fish and fish habitat resources that might be affected by the Project. Freshwater and estuarine fish and fish habitat is considered a valued component (VC) because of the potential for the Project to cause environmental effects during one or more of its development stages, including onshore and offshore site preparation, facilities construction, facilities operation, or Project decommissioning. The TDR is the result of extensive field data collection efforts throughout the local study area (LSA) between April 2012 and December 2013. The TDR describes baseline conditions as a key measure of freshwater and estuarine fish and fish habitat values in the LSA. Information in this TDR will be used in the environmental assessment (the Application) as a basis against which potential effects are assessed.

Data collection methods have been developed from provincial field inventory procedures, to establish baseline conditions, fish presence, fish distribution, relative abundance, and total abundance data. The results of these field studies are relevant to the Application Information Requirements for the VC and are considered in this report in conjunction with historical fish and fish habitat data from other sources including provincial databases, publicly available documents, previous consulting reports and any traditional knowledge that has been provided by Haisla First Nation. LNG Canada has acknowledged that Project infrastructure is located exclusively in the traditional territory of Haisla Nation.

Working in conjunction with Haisla-Triton Limited Partnership technicians, Triton identified a seasonal range of freshwater and estuarine fish and fish habitat values from data gathered throughout the study period. These two aquatic components (i.e., freshwater and estuary) have been assessed as separate sampling programs but are equally relevant given the known or historical presence of economically important Pacific salmon and trout species, culturally significant eulachon, which is listed as *endangered* by the Committee on the Status of Endangered Wildlife in Canada, and all other fish species that occupy one or both aquatic components, such as threespine stickleback, lamprey, sculpins, and starry flounder.

A range of factors influence the seasonal composition of freshwater and estuarine fish species throughout the LSA for the Project and are considered in this TDR:

- known species life history strategies
- physical channel habitat characteristics
- water quality parameters, and
- the combined presence of non-fish aquatic vertebrate taxa.

Four streams constitute the primary freshwater fish habitat in the LSA, which is located on the North Coast of BC at the head of Douglas Channel on the west side of the Lower Kitimat River. The streams include the Kitimat River, Moore Creek, Anderson Creek, and Beaver Creek (the main tributary of Anderson Creek). These streams provide access to extensive perennial and ephemeral secondary off-channel and upstream habitat for numerous fishes of ecological, cultural, and commercial significance.

The Kitimat River is a critical access corridor for migrating anadromous fishes including all five species of Pacific salmon, steelhead and rainbow trout, cutthroat trout, Dolly Varden, and eulachon. All species spawn in habitats upstream of the section of river included in the LSA. Findings show that Kitimat River off-channel habitats to the west of the mainstem support stickleback as well as juvenile coho and chum salmon; no spawning adult salmonids were observed in the Kitimat River and associated off-channel habitat. Eulachon was not observed in the Kitimat River during the study.

Coho salmon is the most abundant and widely distributed species in freshwater mainstem and off-channel habitats of Anderson Creek, Beaver Creek, and Moore Creek. Results indicate annual runs of coho salmon in all streams examined. Anderson Creek is the main tributary of Kitimat River in the LSA; adult coho, pink, sockeye, and chum salmon were observed spawning here during the study period. Coho adults were observed migrating in Beaver Creek, which is the main tributary of Anderson Creek. Rainbow trout and Dolly Varden char were also observed in Anderson and Beaver creeks, along with Pacific staghorn, coastrange, and prickly sculpins. Other fishes include lamprey and threespine stickleback, where habitat conditions permitted.

Anderson Creek and Beaver Creek are perennially hydraulically connected at several points upstream of the main confluence, which provides multiple points of access between these streams for migrating fish. Consequently, although Beaver Creek has reduced spawning potential, it supports a high degree of rearing and overwintering habitat for coho salmon, a portion of which are likely to migrate in from Anderson Creek at all times of the year. Coho salmon and threespine stickleback also occupy off-channel habitats that include the wetland complexes directly off the mainstems of both streams. The complexity and variety of habitat characteristics have led to a high degree of spatial variability in terms of fish distribution and fish habitat suitability in the LSA.

Seasonal factors appear to restrict the availability of off-channel habitat, which influences the timing of fish distribution throughout the LSA. This appears to be partly due to higher temperatures that lead to hypoxic conditions in adjacent wetland complexes. Base flows in late summer also diminish the wetted usable habitat in the mainstems and side channels of these streams, which leads to a reduction in the overall available freshwater habitat and can cause stranding effects for fish that become trapped in ephemeral and anoxic pools.

The most downstream reaches of all freshwater streams in the LSA are subject to tidal influences. Estuarine tidal channels directly downstream of the stream outlets provide transitional habitat for out-migrating salmonid smolts including chum, chinook, coho, pink, and river sockeye salmon. Findings also show a high degree of spatial and temporal variability, but juvenile salmonid presence is most pronounced in the spring during fry emergence. Coho fry and parr also occupy these estuarine tidal channels during spring and fall freshets as a result of flushing events, then appear to return upstream shortly after the flows subside. Threespine stickleback and Pacific staghorn sculpin use the tidal channels perennially and at multiple life stages.

The existing state of the aquatic ecosystem in the LSA has resulted from direct efforts to stabilize natural hydrogeologic and geomorphologic processes in support of ongoing natural resource development. This has led to anthropogenic disturbances that include the construction of protective dikes; road, rail, pipeline, and other linear corridors; stream channelization through industrial sites; leachates from effluent lagoons; hatchery enhancements; landfills; and large industrial footprints, among other land uses. Recreational, subsistence, and commercial fisheries all exist in direct vicinity of the LSA and have also likely influenced the fish community, leading to its current state.

An empirical evaluation of effects to freshwater and estuarine habitat in the LSA has been included as a separate technical report. It has been appended to and is based on the findings of the TDR over the period of study.

ACRONYMS AND ABBREVIATIONS

AFS	Aboriginal Fisheries Strategy
Alcan	Aluminum Company of Canada
BC	British Columbia
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CPUA	catch per unit area
CPUE	catch per unit effort
DBH	diameter at breast height
DFO	Fisheries and Oceans Canada
DO	dissolved oxygen
DU	designatable unit
EcoCat	Ecological Reports Catalogue
Eurocan	Eurocan Pulp and Paper Company
FDIS	Field Data Information System
FHAP	fish habitat assessment procedures
FISS	Fisheries Information Summary System
FSC	food, social, or ceremonial
FSR	forest service road
GIS	geographic information systems
GPS	global positioning system
Haul Road	RTA Wharf “B” access road
HFC	Haisla Fisheries Commission
HU	habitat unit
ha	hectares
IV	instream vegetation
LNG	liquefied natural gas
LNG Canada	LNG Canada Development Inc.
LSA	local study area

LWD	large woody debris
km	kilometres
mm	millimetres
mV	millivolts
N	abundance
ORP	oxidation-reduction potential
OV	overstream vegetation
Project	LNG Canada Export Terminal
q	catchability coefficient
RISC	Resources Information Standards Committee
RoW	Right of Way
RSA	regional study area
RTA	Rio Tinto Alcan
SARA	<i>Species at Risk Act</i>
SWD	small woody debris
t	tonnes
TDR	technical data report
TK	traditional knowledge
TU	traditional use
UTM	Universal Transverse Mercator
VC	valued component

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1 INTRODUCTION

LNG Canada Development Inc. (LNG Canada) is proposing to construct and operate a liquefied natural gas (LNG) facility (including an LNG processing and storage site and marine terminal) in the District of Kitimat, British Columbia (BC), and to export LNG from the facility by shipping. This proposed project is called the LNG Canada Export Terminal (the Project). This Freshwater and Estuarine Fish and Fish Habitat Technical Data Report (TDR) presents background information, methods, and results of the baseline studies conducted for the Project. This assessment is consistent with federal policies and guidelines maintained by Fisheries and Oceans Canada (DFO) and provincial standards held by the BC Oil and Gas Commission Environmental Protection and Management Regulation and the Ministry of Forests, Lands, and Natural Resource Operations (MFLNRO). Relevant legislation includes, but is not necessarily limited to:

- the federal *Fisheries Act*
- the federal *Species at Risk Act (SARA)*
- the provincial *Fish Protection Act*
- the provincial *Forest and Range Practices Act* the provincial *Oil and Gas Activities Act*
- the provincial *Water Act*, and
- the provincial *Wildlife Act*.

The study was initiated with a review of existing information on known fish distribution in the Lower Kitimat River system and its tributaries near the Project. Triton Environmental Consultants Ltd. (Triton) conducted field studies to address the gaps in existing information and to fulfill the requirements for the anticipated Application Information Requirements for the Project's environmental assessment certification.

This TDR comprises all information on fish and fish habitat collected to date in the local study area (LSA; see section 2.2 for definition), including information from existing knowledge sources and databases (described in Section 3), and new information gathered during extensive freshwater and estuarine field programs. Triton used accepted sampling protocols and standard methods to gather baseline information. These methods are described in Section 4.

Observation models were developed to represent the state of the freshwater and estuarine aquatic ecosystems in the LSA, based on collected data. These models were used along with field data to quantitatively evaluate seasonal variation in fish and fish habitat values. Quantitative estimates include:

- fish species presence using seasonally appropriate capture methods (RISC 2001)
- relative abundance based on catch per unit effort (CPUE) and catch per unit area (CPUA)

- total abundance using closed site estimation procedures (Leslie and Davis 1939; Schnute 1983; Walters and Martell 2004)
- fish habitat assessment procedures (FHAP; Johnston and Slaney 1996), and
- surface hydrology and streambed morphology (Lewis et al. 2004).

To address uncertainties, spatial and seasonal variation in fish and fish habitat data for the LSA has been further statistically analyzed; however, Triton acknowledges the limits of using field data to accurately characterize the long-term state of the aquatic ecosystems. Data presented in this report generally span one calendar year, thus providing information on seasonal variation in the life histories of fish species known to occupy the area. An exception is the collection of certain freshwater and estuarine data between late April and early June 2012 and 2013, thus reflecting both seasonal and inter-annual variation. Field results have also considered available historical information on fish and fish habitat, given the Project's scope of development. Results of field studies and historical information should be treated as a baseline from which to develop acceptable mitigation and offsetting measures. The modelling approach used by Triton to evaluate habitat effects, based on the results of this baseline, is further described in Section 5.

2 STUDY AREA

The study area is centrally located in the Kalum Forest District of the Skeena-North Coast Region of BC. At the regional level, it occurs within the Kitimat Ranges Ecosection of the Coastal Gap Ecoregion in the Coast and Mountains Ecoprovince. The climate is influenced by its proximity to the Kitimat Arm of the Douglas Channel, so maritime conditions moderate seasonal temperatures and deliver moisture-laden air into the area, which rises to form precipitation. The inland extension of Douglas Channel, relative to other parts of the North Coast, allows cooler temperatures to prevail in winter.

The region is characterized by a broad valley with prominent postglacial features extending north to the town of Terrace. The Kitsumkalum-Kitimat trough (Clague 1985) is a broad valley that lies within the Coast and Hazelton mountain ranges and consists largely of fluvio-glacial sand, clay, and alluvium deposits from the Pleistocene period (MacDonald and Shepherd 1983). The Kitimat Valley is a separate drainage from the Skeena, located to the north, and is flanked by mountainous terrain that guides the river south to the ocean at Kitimat Arm.

2.1 Regional Setting

All five Pacific salmon species are present within the Kitimat River according to the provincial Fisheries Information Summary System (FISS 2013):

- chinook salmon (*Oncorhynchus tshawytscha*)
- chum salmon (*O. keta*)
- pink salmon (*O. gorbuscha*)
- coho salmon (*O. kisutch*), and
- sockeye salmon (*O. nerka*; river ecotype).

The Kitimat River and tributaries also support other salmonid species including:

- steelhead/rainbow trout (*O. mykiss*)
- cutthroat trout (*O. clarkii clarkii*), and
- Dolly Varden (*Salvelinus malma*).

Anderson and Moore creeks flow into the estuary from the west side of the Kitimat River. Anderson Creek supports chinook salmon, chum salmon, pink salmon, sockeye salmon (river ecotype), coho salmon, rainbow trout, cutthroat trout, and Dolly Varden char, whereas Moore Creek supports chum salmon, pink salmon, coho salmon (Triton 2012), rainbow trout, and cutthroat trout (Triton 2009, 2010).

Cutthroat trout is provincially blue-listed as a species of *special concern* (BCCDC 2012a). Eulachon (*Thaleichthys pacificus*) is also present in the Kitimat River in low numbers (FISS 2013). Among the

designatable units (DUs) for eulachon in BC, the Central Pacific Coast population found in Douglas Channel is federally listed as *endangered* by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2011). Eulachon is also currently being considered for federal listing under SARA and is provincially blue-listed (BCCDC 2012b).

Juvenile chinook and coho salmon are known to rear for extended periods in the lower Kitimat River mainstem and adjacent tributaries while other species, such as pink and chum salmon, migrate to sea from areas in the lower river immediately following fry emergence. Many species of adult and juvenile fish use the lower Kitimat River and its side channels along with adjacent tributaries in surrounding areas for one or more life-history stages.

2.2 Local Study Area

The LSA is dominated by floodplain, wetland, stream, and estuarine ecosystems along the west side of the Kitimat River at the north end of Douglas Channel (Appendix A, Figure A-1). The freshwater aquatic and riparian habitat included in the LSA comprises all named and unnamed streams and side channels west of the Kitimat River mainstem that are expected to interact with Project development activities at any stage. This area includes the portion of the Kitimat River's mainstem channel where the existing Methanex water intake is located, as well as any downstream side channels located directly east of the Project footprint. Estuarine habitat includes tidally-affected channels west of the Kitimat River mainstem that could be affected by onshore and offshore activities at any stage of the Project.

2.3 Regional Study Area

The regional study area (RSA) extends from the head of Douglas Channel south to the entrance of Kitimat Arm and includes all streams, bays, inlets, and coves. The freshwater and estuarine habitats contained within the RSA exist above the average low tide water mark (Appendix A, Figure A-2). The RSA is used to assess the potential for cumulative effects on freshwater and estuarine fish habitats beyond the LSA. The cumulative effects assessment considers residual effects of the Project upstream and downstream, including indirect effects and indirect pathways that could affect other valued components (VCs). Specifically, the RSA comprises all freshwater and estuarine habitats where residual effects may contribute to historical, current, or future effects from existing or planned projects in the area. Cumulative factors could influence any fish population that depends on freshwater or estuarine habitats for at least a portion of its life history.

3 REVIEW OF EXISTING DATA

The study included a review of existing traditional knowledge (TK) related to fisheries, relevant literature, previous and current environmental assessments, and historical fisheries data held in provincial and federal databases.

3.1 Traditional Knowledge

The Project is in Haisla First Nation traditional territory. Haisla Nation was directly involved in the ecological studies conducted for the environmental assessment and has a wealth of TK and traditional use (TU) information on fisheries resources in the RSA. Although TU information has not been considered in this TDR, Triton considers TK to include all means by which Haisla Nation has worked with the government and other parties to develop strategies for managing fisheries that are relevant for food, social, or ceremonial (FSC) purposes. This includes the federal Aboriginal Fisheries Strategy (AFS), established by DFO in 1992 to manage fisheries where any land claims settlement had not yet implemented a formal fisheries management regime (DFO 2012). The Haisla Fisheries Commission (HFC) operates partially through the AFS. Involvement of HFC in the AFS brings a relevant level of TK to the otherwise science-based approach to fisheries management and ecology. This confers benefit to a wider range of interests as it includes the values held by First Nations.

3.1.1 Methods

The inclusion of TK in this TDR has focused on a literature review of publically available documentation. At the time this report was written, Haisla Nation has not provided a TU report to LNG Canada. Methods for providing TK and corresponding fisheries data pertain to Pacific salmon and eulachon. These species are of high importance to the Haisla for FSC purposes. Research has determined that available historical information of documented efforts for management is largely exclusive to these species.

3.1.1.1 Pacific Salmon

Fisheries managers gain knowledge about TU of fish resources by working directly with Haisla Nation members. The AFS has been an effective means of integrating TU and TK through the HFC with conventional management practices (e.g., fishery stock assessment). Previous stock assessments of escapement information for Pacific salmon have been incorporated into this assessment where available (Section 3.2). Historical Aboriginal catch information for Pacific salmon, before the placement of a hatchery on the Kitimat River, has also been taken from DFO documents.

3.1.1.2 Eulachon

A number of rivers in Haisla traditional territory support culturally important eulachon runs (Willson et al. 2006; Moody 2008). The Kitimat River is the primary watercourse in the LSA known to support eulachon historically (Moody 2008; FISS 2013). The Kitimaat Village Council conducted a series of studies through HFC on the population dynamics of eulachon in the Kitimat River (Kelson 1995, 1996, 1997). Information from Aboriginal sources on eulachon in the Kitimat River has been used to incorporate publicly available TK into the assessment.

3.1.2 Results

3.1.2.1 Pacific Salmon

Kitimat River salmon stocks provide an important tidal fishery to Haisla Nation. The average annual catch for the wild fishery, between 1972 and 1980 before hatchery enhancement efforts, included 993 sockeye, 658 coho, 408 pink, 1,021 chum, and 571 chinook salmon (Friedlaender and Reif 1979; MacDonald and Shepherd 1983). Although a modest hatchery began operations in 1977, catch data are representative of wild salmon before the enhancement programs, which expanded the hatchery output in 1983 (DFO 2009). Table 3.1-1 summarizes the annual wild catch.

Table 3.1-1: Annual Catch by Haisla Nation between 1972 and 1980

Year	CH	CM	CO	PK	SK
1972	300	2,000	600	1,000	150
1973	200	1,500	400	100	200
1974	800	1,400	420	50	400
1975	1,300	1,200	500	400	3,000
1976	1,000	800	600	500	1,500
1977	535	535	1,200	–	640
1978	350	530	1,200	575	15,000
1979	350	425	600	150	645
1980	250	300	400	900	900

NOTE:

CH – chinook, CM – chum, CO – coho, PK – pink, SK – sockeye

– No Data

SOURCE: MacDonald and Shepherd (1983)

3.1.2.2 Eulachon

The Kitimat River eulachon run is of historical significance to Haisla Nation and was considered to be the most important run of all rivers in Haisla traditional territory (Moody 2008; COSEWIC 2011; Kelson 1997). Eulachon runs in this Central Pacific Coast DU usually peak in mid- to late-March, but can be delayed into April (Starr 1983). Five of 15 eulachon runs in BC are in the traditional territory of Haisla Nation (Kelson 1997):

- Kitimat
- Kildala
- Kemano
- Kitlope, and
- Kowesas.

Haisla caught large quantities of eulachon prior to 1972. Estimates by DFO show between 27.2 and 81.6 tonnes were caught from 1969 through 1971. Eulachon were mainly consumed (dried and smoked) and were used for the production of grease (Moody 2008). A considerable amount of grease production took place at the “Old Village” (Moody 2008), located directly east of the LSA (Kitamaat1; see Appendix A, Figure A-2). Since 1972, eulachon harvest on the Kitimat River has ceased due to concerns by the Haisla about industrial pollution (Tirrul-Junes 1985) and a decline in abundance (see Section 3.2). As a result, the Haisla now travel south to Kemano River or nearby Kildala River to fish for eulachon (COSEWIC 2010).

Haisla Nation studied Kitimat River eulachon between 1994 and 1997 during the Kitamaat Village Council Eulachon Study, which was predominantly driven by concerns about logging practices and the potential effects on eulachon habitat. Results showed adult returns commencing February 21, with a peak run time between March 11 and 18 (during peak river discharge), and extending as late as May 13 (Kelson 1997). In 1997, the study captured 1,546 adults (509 females and 1,037 males) aged 2 to 6 years (average age of 4 years; $n = 300$). Kelson (1997) also observed diurnal egg outdrift ranging from less than 0.5 to greater than 3 eggs/m³, significantly lower than that observed in the Kemano River (>80 eggs/m³) and the Wahoo River (>100 eggs/m³) during the same year.

3.1.3 Discussion

The TK discussed in this section is largely derived from DFO's scientific methods for fisheries management, and HFC's partnership with DFO through the AFS. There is value in trying to apply the more recent historical catch rates by Haisla Nation; however, the information presented in this section is not sufficient to fully describe TU of fish species in the LSA, particularly eulachon and the procurement of grease as a trade commodity. Aboriginal knowledge about fish species, whether for FSC purposes or otherwise, is equally relevant to the description of fish and fish habitat as a VC in the assessment.

The influences of previous industrial developments and fisheries enhancement efforts on fish and fish habitat in the LSA are highly relevant to this baseline in the context of TU, especially given the current status of Kitimat River eulachon and Pacific salmon.

Fish is important to Haisla Nation subsistence; additional effort will be necessary to consider TK of fish and fish habitat in the LSA throughout the environmental assessment process.

3.2 Literature Review and Previous Investigations

Historical data provide information on fish and fish habitat in the RSA. Factors of interest include fish species distribution, barriers to fish movement, general habitat quality, and the findings of previous studies that show how external variables are likely to influence fish and fish habitat in the LSA. Development activities directly upstream of the Project in the RSA have influenced watercourses leading into the Project area. Developments include the Eurocan Pulp and Paper Company (Eurocan) fibre mill site owned by West Fraser Timber Co. Ltd. and recently acquired by the consortium of companies developing the Kitimat LNG project. They also include the existing Rio Tinto Alcan (RTA) facility and its surrounding infrastructure (numerous dikes, roadways, rail corridors, and transmission Rights of Way [RoWs]). Historical information on fish and fish habitat in the RSA is relevant to this assessment because these developments have led to the current physical state of the aquatic ecosystems and habitats that support the fish community in the LSA.

3.2.1 Methods

Before commencing field programs, Triton consulted credible online databases and web applications with document control systems in place. Sources included government databases and interactive map tools (both provincial and federal):

- Fisheries Information Data Queries provincial databases, including species distribution information from FISS
- inventory reports from the Field Data Information System (FDIS)

- interactive databases (e.g., Habitat Wizard, iMapBC) with mapped fish points and known obstructions, and
- stocking/hatchery information from the Kitimat River Hatchery located directly upstream of the Project area along the Kitimat River.

Escapement data from DFO databases was available to evaluate historical spawning abundance of Pacific salmon within the RSA. The Ecological Reports Catalogue (EcoCat), academic sources, and other publicly available documents provided existing relevant studies.

Table 3.2-1 lists the primary sources of information about baseline freshwater and estuarine fish and fish habitat used to support the assessment. Relevant publically available data from the following current developments have been included:

- Northern Gateway Pipeline Project (Whelen and Bradley 2010)
- Kitimat-Summit Lake Pipeline (now Pacific Trail Pipeline), and
- Kitimat LNG Terminal Project.

Table 3.2-1: Primary Information Sources for Freshwater and Estuarine Fish and Fish Habitat

Data Source	Information Provided
Literature review	Many sources are cited throughout the TDR and are listed in Section 8.0.
Fisheries Information Summary System (FISS) online database: http://www.env.gov.bc.ca/fish/fiss/	Spatial summary of fish and fish habitat data including fish distribution, escapement, and life history and timing. This tool also provides references to data sources.
Ecological Reports Catalogue (EcoCat) online database: http://www.env.gov.bc.ca/ecocat/	Publicly accessible digital reports and publications on previous fish and fish habitat assessments, as well as fisheries data and fish capture locations submitted to Ministry of Environment through FDIS as a requirement of scientific fish collection permits (BCMOE 2013a).
Habitat Wizard interactive mapping database: http://www.env.gov.bc.ca/habwiz/	Public database administered through Ministry of Environment to provide spatial data on previous fish capture and habitat characteristics in the province (BCMOE 2013b).
iMapBC, interactive mapping database: https://apps.gov.bc.ca/pub/dwds/home.so	Publicly available database with spatial information on fish and fish habitat provided by consultants and government through FDIS, FISS, and EcoCat (BCMOE 2013c).
MAPSTER v3.1 interactive mapping tool: http://www.pac.dfo-mpo.gc.ca/gis-sig/maps-cartes-eng.htm	Publicly accessible DFO database with information on Pacific salmon escapement, inland and marine ecology, physical geographic features, and First Nations.
Terrain Resource Information Management internet database: http://archive.ilmb.gov.bc.ca/crgb/pba/trim/	Publicly accessible GeoBC database of data layers that provide topographical information and include features such as roads, streams, and forest openings.
Google Earth Pro® web application: http://www.google.com/earth/learn/	A web application that allows for an aerial view of the Earth's surface. This tool was used to provide information on site access and channel characteristics.

Data Source	Information Provided
British Columbia Species and Ecosystems Explorer internet database: http://www.env.gov.bc.ca/atrisk/toolintro.html	Public database providing spatial and ecological conservation information (e.g., COSEWIC status, SARA listing, and Conservation Data Centre listing) on relevant faunal species and ecosystems.
BC Freshwater Atlas: http://www.ilmb.gov.bc.ca/geobc/FWA	A standardized database of freshwater inventories in BC.

The listed sources informed the design and implementation of the freshwater and estuarine fisheries field programs.

The pre-field desktop exercise identified and mapped watersheds and their boundaries. Triton compiled fisheries information for waterways in the LSA on a 1:20,000 map and identified specific interim locational points for fish sampling and detailed habitat assessments in the LSA. This set of Universal Transverse Mercator (UTM) coordinates was then transferred onto individual handheld global positioning system (GPS) units for field surveys.

3.2.2 Results

3.2.2.1 Kitimat River

The Kitimat River (watershed code 910-673500; waterbody identifier 00000KITR) is on the north-central coast of BC with a drainage area of approximately 200,000 ha (Warrington 1987). The river flows approximately 75 km from Mount Davies north, west, and then south to Kitimat Arm in Douglas Channel (MacDonald and Shepherd 1983). Kitimat River supports multiple freshwater and anadromous species, including all five Pacific salmon (chinook, coho, chum, pink, and sockeye; Appendix A, Figure A-4), trout (steelhead, rainbow, and cutthroat; Appendix A, Figure A-5), char (Dolly Varden; Appendix A, Figure A-6), and several non-salmonid species (MacDonald and Shepherd 1983; FISS 2013). Eulachon also spawns in the Kitimat River mainstem and side channels directly adjacent to the LSA (Pedersen et al. 1995; Appendix A, Figure A-7). Juvenile salmonids, eulachon, and other freshwater and nearshore marine fish species are known to spawn and rear for extended periods in the Kitimat River estuary within the RSA. Appendix B summarizes background fisheries data collected for the TDR.

In addition to wild fish production, Kitimat River Hatchery releases approximately 11 million fish annually (Table 3.2-2), including five salmonid species: chinook salmon, coho salmon, chum salmon, steelhead trout, and cutthroat trout. The hatchery was established roughly 2 km west of the Kitimat town site and directly north of the LSA. Chinook salmon return to the estuary between June and August, coho salmon return between August and October, chum salmon return during July and August, steelhead return between March and May, and cutthroat trout return in all months of the year.

Table 3.2-2: Kitimat Hatchery (1998 to 2012) Releases by Species

Year	CH	CM	CO	ST	CT	Total
1998	1,897,653	5,827,122	521,160	54,696	11,897	8,312,528
1999	1,677,031	6,341,451	734,490	64,297	7,011	8,824,280
2000	1,705,926	4,341,672	522,333	85,144	2,915	6,657,990
2001	1,742,919	4,538,316	634,273	40,147	6,285	6,961,940
2002	1,752,095	4,921,186	498,328	46,566	1,288	7,219,463
2003	1,603,822	4,957,773	464,898	59,885	9,011	7,095,389
2004	1,484,453	4,338,437	468,552	69,373	8,330	6,369,145
2005	1,463,783	4,334,899	401,290	47,000	4,400	6,251,372
2006	1,634,795	4,809,420	529,661	72,417	2,463	7,048,756
2007	1,647,816	4,622,504	412,023	39,684	13,126	6,735,153
2008	1,727,621	3,380,600	458,238	48,277	2,324	5,617,060
2009	1,429,140	1,457,826	410,730	57,808	4,580	3,360,084
2010	1,924,241	3,675,243	536,876	53,791	n/a	6,190,151
2011	1,473,394	1,688,600	281,012	28,494	n/a	3,471,500
2012	1,987,994	2,214,441	555,461	45,434	n/a	4,803,330

NOTE:

CH – chinook, CM – chum, CO – coho, CT – cutthroat, ST – steelhead

SOURCE:

DFO (2013)

Eulachon is anadromous and migrates upstream annually in the Kitimat River to spawn at night during high tide, between late February and May (BCCDC 2012b). The preferred spawning substrates include bar and riffle habitat containing sand or pea-gravel (McPhail 2007). Emerging larvae are carried downstream to the estuary. Eulachon larvae typically mature in 3 years (Hay and McCarter 2000), although Pederson et al. (1995) observed adults aged 5 or 6 years in the lower Kitimat River. A typical adult freshwater phase lasts about 4 weeks to ensure successful spawning, after which it dies. Hay and McCarter (2000) note that fecundity ranges from about 3,000 eggs (small Kitimat River females) to nearly 60,000 eggs (largest Fraser River females). Emergent larvae are 4-8 mm in length (McPhail 2007) when they passively migrate to estuaries about 6 to 8 weeks after spawning occurs (Hay and McCarter 2000). They disperse to fjord entrances, but remain in fjords over successive months (Hay et al. 1997).

In 2000, eulachon populations along BC's central coast had declined to remnant levels in the Stikine, Unuk, Skeena, Kitimat, Kemano, Kitlope, Bella Coola, Kimsquit, Owikeeno, and Kingcome rivers. Pederson et al. (1995) estimated a total spawning eulachon biomass in the lower Kitimat River of about 514,000 individuals in 1993. The CPUE data for eulachon on the Kitimat River declined from 50 fish per

24-hour gill net set (1994 to 1996) to less than 2 fish per 24-hour gill net set in 1998 (EcoMetrix 2006). According to EcoMetrix (2006), abundance of eulachon has declined from annual returns of 527,000 fish in 1994 to between <1,000 and 13,600 fish since 1998.

3.2.2.2 Anderson Creek

Anderson Creek (watershed code 910-673500-03300) is the principal tributary of the Kitimat River in the LSA. It is 12.78 km long (FISS 2013) and flows east from the Coast Mountains to west of the RSA through a channelized section of the RTA Wharf “A” aluminum facility in the LSA. The channelized section was previously subjected to dredging (Mitchell 2012, pers. comm.) and currently contains a series of weirs put in place for fish habitat enhancement. Anderson Creek contains a barrier falls upstream of Haisla Boulevard along the west perimeter of the aluminum facility.

According to FISS (2013), salmonid species in Anderson Creek include chum, pink, and coho salmon. Additional salmonids identified in previous investigations include chinook and sockeye salmon, cutthroat trout, and Dolly Varden char (iMapBC 2013; Table 3.2-3). Other species observed include Pacific lamprey (*Lampetra tridentata*), threespine stickleback (*Gasterosteus aculeatus*), Pacific staghorn sculpin (*Leptocottus armatus*), and starry flounder (*Platichthys stellatus*; iMapBC 2013).

3.2.2.3 Beaver Creek

Beaver Creek (watershed code 910-673500-03300) is not gazetted according to FISS (2013); it is the first tributary of Anderson Creek to flow into the LSA. Beaver Creek originates in the Coast Mountains to the northwest, and borders the Eurocan mill site along the west and south perimeters before crossing Haisla Boulevard (formerly Alcan Way) and entering the LSA. Beaver Creek has historically been subject to significant waste loading from leachate at old landfill and refuse sites from the mill, which have progressively deteriorated the water quality over time (Warrington 1987). Warrington (1987) also noted that coho salmon uses Beaver Creek as spawning habitat. Additional species observed in Beaver Creek include rainbow trout, cutthroat trout, and Dolly Varden char (iMapBC 2013; Table 3.2-3).

3.2.2.4 Moore Creek

Moore Creek (watershed code 910-674000) is the southernmost stream on the west side of the Kitimat River flowing east from the Coast Mountains. It is 10.26 km long (FISS 2013) and roughly parallel to Anderson Creek. Moore Creek falls is a known fish barrier that is located immediately upstream of Haisla Boulevard. Like Anderson Creek, Moore Creek has been channelized through the RTA facility. RTA facility operations have historically affected the water quality downstream on Moore Creek, including pH to an observed minimum of 3.6. It has exceeded aquatic life criteria for metals including aluminum, iron, fluoride, and zinc (Warrington 1987).

According to FISS (2013), coho and pink salmon have been observed in Moore Creek. Additional fishes recorded in Moore Creek include cutthroat trout, rainbow trout (Triton 2009, 2010), threespine stickleback, coastrange sculpin (*Cottus aleuticus*), and prickly sculpin (*Cottus asper*; iMapBC 2013). Table 3.2-3 summarizes previous fish observations in the streams of the LSA.

Table 3.2-3: Freshwater and Anadromous Fishes Recorded in the LSA of the Kitimat River Watershed

Species	Anderson Creek	Beaver Creek	Moore Creek	Kitimat River
Chinook salmon	✓	–	–	✓
Chum salmon	✓	–	✓	✓
Coho salmon	✓	✓	✓	✓
Pink salmon	✓	–	✓	✓
Sockeye salmon	✓	–	–	✓
Steelhead trout	–	–	–	✓
Rainbow trout	✓	✓	✓	✓
Cutthroat trout	–	✓	✓	✓
Dolly Varden	✓	✓	–	✓
Eulachon	–	–	–	✓
Lamprey (general)	–	–	–	✓
Threespine stickleback	–	–	✓	✓
Coastrange sculpin	–	–	✓	✓
Prickly sculpin	–	–	✓	✓
Pacific staghorn sculpin	–	–	–	✓
Starry flounder	✓	–	–	–

NOTE:

- ✓ recorded
- not recorded

SOURCES:

iMapBC (2013); FISS (2013)

3.2.2.5 Kitimat River Estuary

Estuarine habitat is important to both marine and anadromous fishes. The Kitimat River estuary is an extensive continuum of intertidal habitat that receives both freshwater and marine inputs. Estuaries support unique plant communities that have adapted a tolerance to both marine and freshwater conditions. Fishes that use these habitats must be physiologically capable of such osmotic tolerance either consistently or at some stage in their life history, as with anadromous fishes.

Kitimat Arm generally contains brackish surface water with highly variable salinity, largely affected by seasonal conditions that influence tides and the amount of freshwater input. Slaney et al. (1982) have described the estuary as a large sediment deposit extending from the mouth of the Kitimat River to encompass all the foreshore extending to the western edge of Douglas Channel and roughly halfway into Minette Bay to the east side. This vast tidal flat contains numerous channels and extends approximately 1 km out from land before dropping off sharply to a depth of 145 m at the channel floor. Webster (1980) noted that the salt wedge below the surface lens maintains relatively constant salinity at $31 \pm 0.5\%$ at a depth of 50 m year round.

Previous studies have shown that the estuarine habitats in the LSA have been heavily modified and disturbed by the wharves and effluent discharge from Methanex (formerly Ocelot Industries Ltd.) and Eurocan (Warrington 1987). Rio Tinto Alcan owns the foreshore and shoreline that would comprise all estuarine habitat on the west side of Kitimat Arm.

Studies of Kitimat River juvenile salmonid outmigration and estuarine rearing (abundance and timing) have been completed over the past number of decades, although no recent information exists. Slaney et al. (1982) determined that the majority of salmonid fry and smolts had emigrated from the river by late April and May of each year (Table 3.2-4).

Table 3.2-4: Timing of Juvenile Salmonid Migration to the Kitimat River Estuary – 1980

Species	10% Completion	50% Completion	90% Completion
Pink fry	April 8	April 11	April 23
Chum fry	April 8	April 12	April 19
Chinook smolts	April 13	April 26	May 12
Coho smolts	April 12	April 27	June 22

SOURCE:

Slaney et al. (1982)

Early life history studies determined that juvenile chum, coho, and chinook salmon use the estuary and tidal channels extensively in the Kitimat area and in Minette Bay (Slaney et al. 1982). To a lesser extent, juvenile and adult cutthroat and Dolly Varden also make use of the area, which is historically important habitat to eulachon, threespine stickleback, Pacific staghorn sculpin, starry flounder, and Pacific herring (*Clupea pallasii*), among other species.

4 FIELD STUDIES

The freshwater and estuarine reconnaissance-level surveys were developed based on methods provided by Johnston and Slaney (1996) and RISC (2001). The framework and associated standards for the freshwater field assessments were based on Lewis et al. (2004). Estuarine field assessments provide baseline information with consideration of existing development activities from RTA Wharf “A”, RTA Wharf “B” and Methanex jetty, and the associated ancillary infrastructure (dikes, roadways, landfills, pipelines, and outfalls).

4.1 Freshwater Fish and Fish Habitat

The primary objective of the freshwater component of the assessment was to collect sufficient data to adequately describe baseline conditions in the LSA to support the environmental assessment. Triton identified and assessed the following:

- fish habitat in the LSA across a range of seasons and flow stages
- fish species assemblages in the LSA in terms of distribution, relative abundance, life history stage, and use of critical habitats found within the LSA, and
- distribution, relative abundance, and habitat use by provincially and federally listed species of concern that are potentially vulnerable to environmental effects of the Project.

The assessment of fish and fish habitat involved the following tasks:

- description of in situ basic water quality parameters: temperature, dissolved oxygen (DO), conductivity, pH, and turbidity from selected watercourses
- reconnaissance-level fish habitat descriptions to characterize watercourses in the LSA to help identify habitat offsetting opportunities
- documentation of incidental observations of fish passage barriers upstream of, within, or downstream of watercourses in the LSA, and
- characterization of fish captured in the LSA by species, length, and weight.

Fish habitat conditions are described following FHAP (Johnson and Slaney 1996) conducted on watercourses in the LSA. A modified reconnaissance-level survey (1:20,000; RISC 2001) was also completed at all sample sites.

4.1.1 Methods

The following watercourses were included in the study:

- Kitimat River
- Anderson Creek
- Beaver Creek (principal tributary of Anderson Creek), and
- Moore Creek.

To ascertain potential effects of the Project on local fish populations, as opposed to external variables such as floods or other climatic events, it is useful to have some measure of fish production outside of the Project’s area of influence. Cecil Creek, a Kitimat River tributary located approximately 20 km north of the Project, was used as a control stream with comparable habitat characteristics. It served as a reference site that was monitored concurrently with the streams located in the Project area.

All freshwater sampling took place over the course of May 2012 to December 2013, which allowed for detection of any shifts in quality and quantity of available habitat according to season and stage of stream discharge. Biophysical, hydrologic, and water quality data were collected from most sites over multiple sampling sessions (see Table 4.1-1). The primary means of fish capture consisted of backpack electrofishing and minnow trapping, as seasonal conditions permitted.

Table 4.1-1: Transect Locations Successfully Sampled in Each Season

Creek	Transect	UTM	May-12	Jun-12	Sep-12	Jan-13	Mar-13
Anderson	AT1	9U 519935 5985779	✓	✓	✓	✓	–
Anderson	AT1A	9U 519943 5985776	–	–	✓	–	–
Anderson	AT2	9U 519997 5985826	✓	✓	✓	✓	✓*
Anderson	AT3	9U 520028 5985857	✓	✓	✓	✓	–
Anderson	AT4	9U 520095 5985842	✓	✓	✓	✓	✓*
Anderson	AT5	9U 520231 5985715	✓	✓	–	✓	–
Anderson	AT5A	9U 520262 5985730	–	–	✓	✓	–
Anderson	AT6	9U 520320 5985466	✓	✓	✓	✓	–
Anderson	AT7	9U 520453 5985393	✓	✓	✓	✓	–
Anderson	AT8	9U 520699 5985187	✓	✓	✓	✓	✓*
Beaver	BT1	9U 519183 5987299	–	–	–	✓	✓
Beaver	BT2	9U 520188 5986496	✓	✓	✓	✓	–
Beaver	BT3	9U 520203 5986480	✓	✓	✓	✓	–
Beaver	BT4	9U 520298 5986230	✓	✓	–	–	–
Beaver	BT4A	9U 520277 5986229	–	–	✓	✓	–

Creek	Transect	UTM	May-12	Jun-12	Sep-12	Jan-13	Mar-13
Beaver	BT5	9U 520551 5985785	✓	✓	✓	–	✓*
Beaver	BT6	9U 520790 5985401	✓	✓	✓	–	✓*
Moore	MT1	9U 520693 5985150	✓	✓	✓	–	–
Moore	MT2	9U 520694 5984922	✓	✓	✓	–	–
Moore	MT3	9U 520403 5984858	–	–	✓	✓	–
Moore	MT4	9U 520429 5984837	–	–	✓	✓	–
Moore	MT5	9U 520519 5984794	–	–	✓	✓	–
Cecil	CT1	9U 523076 6015377	–	✓	–	–	–
Cecil	CT2	9U 522996 6015205	–	✓	–	–	–
Cecil	CT3	9U 522998 6015186	–	✓	–	–	–
Cecil	CT4	9U 522983 6015173	–	✓	–	–	–
Cecil	CT5	9U 522977 6015097	–	✓	✓	–	–
Cecil	CT6	9U 522982 6015085	–	–	✓	–	–

NOTE:

- ✓ indicates full habitat sampling
- ✓* indicates discharge transects only
- not sampled

4.1.1.1 Freshwater Fish Habitat Assessments

Sample sites were selected to be representative habitats within each watercourse. Each site included a station for measuring flow characteristics throughout each stream. Flow transects in the mainstem channel of each creek were used to measure depth and velocity across the wetted channel and determine stream discharge using standard methods for characterizing aquatic habitat and instream flow (see Lewis et al. 2004).

May 2012

Fifteen transect stations were established for the May 2012 sampling session: eight along Anderson Creek, five along Beaver Creek, and two in a slough that was a former side channel of Moore Creek that flows into lower Anderson Creek (Appendix A, Figure A-3). A small dike near a high-voltage transmission tower blocks surface flow of this side channel between Moore Creek and Anderson Creek.

The data form developed for the study included metrics from a standard RISC (2001) site card with additional comments on migration, spawning, rearing, overwintering, staging, and holding habitat. This information was used to evaluate the suitability of each transect location for different salmonid life stages. Water quality parameters measured included stream temperature (°C), conductivity (µS/cm), and pH

(using a Hanna® handheld combo meter); turbidity was assessed visually (RISC 2001). Photos were taken upstream and downstream of each transect with features noted and including a sketch of the channel at each site.

A crew mapped the mainstem habitat in all watercourses. In May 2012, surveyors followed Anderson and Beaver creeks from the confluence located south of the Project area and continuing upstream to the uppermost transect of each creek. One surveyor mapped the centerline of the channel with a handheld GPS, measuring the length of each channel unit using a hip chain, while the other surveyor captured wetted width measurements. The crew conducted GIS surveys using orthophoto coverage to ground-truth all creeks and side channels for horizontal positioning; line work was overlaid on the LiDAR surface for area mapping McElhanney (2012). This complemented the Level 1 FHAP surveys (Johnston and Slaney 1996) and provided the means for assessing the relative amount of channel units, including pool, run, riffle, and cascade habitats beyond the transect locations.

June 2012

During June 2012, Triton established six new reference sites on Cecil Creek (Table 4.1-2). The reference transects were treated similarly to the other transect sites established in the LSA. Assessment methods used for quality and quantity of fish habitat were the same for all transects.

September 2012

During September 2012, a low stage of stream discharge was observed and extensive beaver activity had altered the wetted areas that were previously observed during June in some parts of the creeks in the LSA and in Cecil Creek. Some transect locations became unsuitable for measuring habitat and flow conditions. Triton established several new transects in the LSA.

- Transect AT1A supplemented the data recorded for AT1 and AT2 transects.
- Transect AT5A was placed in an adjacent braid due to dewatering of AT5.
- Transect BT4A was placed upstream of Transect BT4, which was flooded by a beaver pond.
- Three new transects, MT3, MT4 and MT5, were established on the mainstem of Moore Creek.

Dewatering of the upstream portion of the Cecil Creek assessment area eliminated all fish habitat for CT1 through CT4 so only habitat data for transects CT5 and CT6 could be collected. Discharge measurements were not taken in Cecil Creek due to indiscernible flow between the residual pools areas.

Additional reconnaissance efforts revealed the presence of a large side channel (i.e., Anderson Creek North) that flows from Anderson Creek upstream of AT4 and continues north, parallel to the RTA Wharf "B" access road (the Haul Road) on the west; the side channel then crosses the road through a

cluster of culverts and continues north on the east side of the access road, and eventually flows into Beaver Creek upstream of BT4 and BT4A. No new transects were established in this channel.

November and December 2012

Triton visited additional sites during the November and December estuary sampling events (Section 4.2). These involved sampling several wetted areas in the LSA that were previously observed (but not sampled) in the 2012 freshwater program. Several wetted areas, with no obvious connectivity, had standing water in a partially forested wetland west of the Haul Road and east of a rail spur extending south to the RTA facility. Reconnaissance also included a visit to a Kitimat River oxbow and side channel that flows in from the north on the east side of the LSA. A brief reconnaissance in the upper section of Beaver Creek indicated the need for additional sampling effort. Upper Beaver Creek extends to the west and north along the perimeter of the existing Eurocan mill site. It is upstream of the wetland complexes near the Methanex facility.

January 2013

The January field session had to be modified because of winter conditions in Kitimat and the RSA. The transect survey crew was unable to access MT1, MT2, BT5 and BT6 due to unsafe site conditions (snowpack and tidal influence) and reduced day length. The survey crew completed a full Level 1 FHAP of Anderson Creek from the Beaver Creek confluence to AT1.

January 2013 included additional reconnaissance trips directly south of Anderson Creek and west of the Haul Road, where a previously constructed side channel had been discovered. Another trip to the Kitimat River side channels examined fish habitat from the ponds extending south toward a prominent dike running southeast through the LSA.

March 2013

During the March session, the survey crew repeated sampling at the newly established BT1 transect to include both discharge and Level 2 FHAP information. Habitat information had already been collected for the remaining sites across a sufficient range of seasonal and stage conditions. Previous sampling sessions indicated a need to gather more information on water quality, channel connectivity, and surface flow exchange between creeks in the LSA. Additional water quality parameters were measured in specific sites using a YSI Professional Plus® water quality meter that measured dissolved oxygen (DO; % and mg/L), salinity (‰), and oxidation-reduction potential (ORP; mV).

Triton observed perennial side channel habitats that allow for substantial exchange of surface flows in the LSA between Anderson and Beaver creeks. Off-channel wetland habitat was observed above BT2, the

uppermost transect on Beaver Creek, during 2012. The habitat upstream of BT2 exists near the Methanex facility, the rail spur, and nearby wetland complexes (Appendix A, Figure A-3).

The side channel and off-channel habitats added complexity to the system in terms of fish distribution throughout the LSA. To better understand the path of surface flow throughout the LSA, discharge measurements were taken in March 2013 at sites on Anderson and Beaver creeks:

- single channels above all known points of surface exchange (i.e., AT2 and BT1)
- braided channels within the area of surface exchange (i.e., AT4 and BT5), and
- single channels below all observed side channel habitats in either creek (i.e., AT8 and BT6).

May 2013

This final survey for the freshwater fish habitat study was intended to map the side channel habitats west of the dike and more closely examine Beaver Creek's off-channel wetland habitat near the old Methanex facility. The survey crew mapped the side channel and off-channel habitat between May 17 and May 19, 2013, considering the wetted areas mapped in the mainstem habitat during May and June 2012. This mapping allowed for an estimation of habitat availability in terms of total wetted area and high water refuge (Millar et al. 1997) during comparable flow stages of stream discharge. Habitat mapping included measurement of total length and average wetted width, and a visual characterization of each side channel as perennial, ephemeral (dry intermittent), or dewatered.

Based on the total wetted areas determined through the May 2013 side channel mapping, it was possible to estimate total riparian habitat in the LSA. The estimate considered the mainstems of Anderson, Beaver and Moore creeks, as well as all off-channel habitats west of the Kitimat River.

4.1.1.2 Freshwater Fish Sampling

Fish capture methods included both backpack electrofishing (EF) and minnow trapping. Minnow traps included baited Gee traps (GT) as well as mesh traps (MT) that select for larger fish. As seasonal conditions permitted, electrofishing included both open- and closed-site methods. Closed-site fish capture comprised a multiple-pass electrofishing depletion removal method. In addition to sampling in creeks, fish capture effort was extended into the wetted areas in the LSA as described in Section 4.1.1.1. These areas included the pool habitats west of the Haul Road and the wetland complexes extending off Beaver Creek near the old Methanex facilities site (i.e., Upper and Lower Wetland Complexes), the slough on the north perimeter of the LSA and adjacent to effluent lagoons (i.e., Eurocan slough), wetted habitats on either side of the dike (i.e., Dike Area), and the side channels and oxbows extending west off the Kitimat River mainstem (i.e., Kitimat River West; Appendix A, Figure A-3). See Table 4.1-2 for a summary of all capture methods employed throughout the LSA. Appendix C, Table C-2, further lists all detailed site data and corresponding capture methods within each location area of the LSA.

Table 4.1-2: Fish Capture Methods

Location Area	Method	May-12	Jun-12	Sep-12	Dec-12	Jan-13	Mar-13	May-13
Anderson Creek	GT	✓	✓	✓	–	✓	✓	–
Anderson Creek	MT	–	–	✓	–	✓	–	–
Anderson Creek	EF (open)	✓	✓	–	–	–	–	–
Anderson Creek	EF (closed)	✓	✓	✓	–	–	–	–
Beaver Creek	GT	✓	✓	✓	–	✓	✓	–
Beaver Creek	MT	–	–	✓	✓	✓	✓	–
Beaver Creek	EF (open)	✓	✓	–	–	–	–	–
Beaver Creek	EF (closed)	✓	✓	–	–	–	–	–
Moore Creek	GT	✓	✓	✓	–	–	–	–
Moore Creek	MT	–	–	✓	–	–	–	–
Moore Creek	EF (closed)	–	–	✓	–	–	–	–
Cecil Creek (reference)	GT	–	✓	–	–	–	–	–
Cecil Creek (reference)	EF (closed)	–	✓	✓	–	–	–	–
Wetland Complexes	GT	–	–	–	–	✓	✓	✓
Wetland Complexes	MT	–	–	–	–	✓	–	✓
Wetland Complexes	EF (open)	–	–	–	–	–	–	✓
Eurocan Slough	GT	–	–	–	–	–	✓	–
Dike Area	GT	–	–	–	–	–	✓	✓
Dike Area	MT	–	–	–	–	–	✓	–
Kitimat River West	GT	–	–	–	–	–	✓	–
Kitimat River West	MT	–	–	–	–	–	✓	–
Kitimat River West	DN	–	–	–	–	–	✓	–

NOTE:

✓ sampling occurred

– not sampled

EF – electrofishing, DN – dip net, GT – Gee trap, MT – mesh trap

May 2012

During May 2012, freshwater fish were sampled throughout areas where the initial transects had been established in the mainstem of Anderson Creek and Beaver Creek, as well as the former side channel slough of Moore Creek. A closed-site depletion removal electrofishing method was used in the mainstem of Anderson Creek and Beaver Creek, and in a side channel of Anderson Creek. Sampling involved standardized effort across passes in distinct channel units. Triton examined most of the assessment areas in these channels, as well as the primary inter-connecting side channels (i.e., Anderson Creek North and Anderson Creek East channels; Appendix A, Figure A-3) by electrofishing open sites. Water levels and conditions in Moore Creek slough created unsafe conditions for backpack electrofishing.

Triton deployed Gee minnow traps throughout the assessment area of Anderson Creek, as well as in Anderson Creek North channel up to the culverts under the Haul Road. Sections of mainstem Beaver Creek and the Moore Creek slough were also sampled using Gee minnow traps.

June 2012

Fish sampling in June was similar to that completed in May 2012 with a replication of open- and closed-site electrofishing in Anderson and Beaver creeks; however, the area of closed sites in Anderson Creek was slightly less than that in May due to the unsafe wading conditions created by the increased depths and velocities. Gee minnow trapping locations were similar to those in May.

The field crew also conducted closed-site electrofishing and Gee minnow trapping in the mainstem of the control stream (Cecil Creek). The level of effort for this sampling was similar to efforts within the LSA.

September 2012

The September visit coincided with annual spawning for several species of Pacific salmon. Sampling crews attempted to avoid setting traps and electrofishing in areas with a high density of spawners and redds. Fish capture included larger mesh traps along with the smaller Gee traps to increase the capture probability, or catchability (q), over a wider range of age classes. Due to the high densities of fish observed, soak times were reduced to ensure that relative abundance estimates would not be influenced by changes in q over time due to crowding effects in individual traps.

Additional fish sampling took place in the mainstem of Moore Creek near the newly established transects MT3 - MT5. Sampling included closed-site electrofishing involving standardized effort across passes in distinct channel units. Additional sampling included minnow trapping using Gee traps and the larger mesh traps.

The September survey involved closed-site electrofishing in Anderson, Moore, and Cecil creeks, but not Beaver Creek. Minnow trapping in Beaver, Anderson, and Moore creeks supplemented electrofishing

effort. Large mesh traps were also set overnight in the Anderson Creek North channel where it crosses the Haul Road through the cluster of culverts (Appendix A, Figure A-3).

December 2012

During the November reconnaissance trip to examine additional wetted areas in the LSA, Triton observed numerous fish in Upper Beaver Creek (BT1). The crew returned to this location during the December estuary trip to set large mesh traps overnight in the same location.

January 2013

Fish sampling in January included minnow trapping (both trap types) in Beaver, Anderson, and Moore creeks, with resampling to assess winter fish use compared to previous seasons at the same locations. The crews placed additional traps in Anderson and Moore creeks at locations that had not previously been sampled for fish presence. Due to the low stream temperature in January (<4°C), electrofishing was prohibited under the Ministry of Environment fish collection permit and DFO scientific license conditions.

Given the amount of wetted habitat observed during the fall reconnaissance trips, additional trapping included the Lower Wetland Complex, predominantly at the outfalls of two culverts that drain the wetted areas west of the Haul Road (Appendix A, Figure A-3). The channels enter Beaver Creek in the Lower Wetland Complex from the west. Trapping effort included a third culvert where several large ponds had been observed between Haisla Boulevard and the Methanex access road (i.e., the northern part of the Upper Wetland Complex). This culvert crosses under Haisla Boulevard and possibly connects these ponds to Beaver Creek to the northwest, although it was difficult to assess the direction of flow during the January survey. The crew placed Gee traps on each side of the culvert overnight. Crews also re-sampled the Anderson Creek North channel on either side of the cluster of culverts to compare winter use in side channel habitats with the September survey.

March 2013

Fish sampling in March focused on the peripheral wetted areas and off-channel habitats that had been identified, but not previously sampled for fish. Observations from previous field sessions included the Dike Area, which separates all surface flow to the west (i.e., Anderson, Beaver, and Moore creeks) from surface flows and standing waterbodies to the east that connect with Kitimat River side channels. The side channels are near areas where eulachon had previously been observed (Appendix A, Figure A-7). Other Triton biologists observed that eulachon had commenced spawning migrations in the Kemano River in March (Frederiksen 2013, pers. comm.), which coincided with the March 2013 freshwater survey. A field crew set minnow traps throughout the Kitimat River side channel and oxbow area (i.e., Kitimat River West; Appendix A, Figure A-3) extending north of the oxbow channel to the river's mainstem and

south toward the Dike Area and estuary beyond. Low temperatures precluded electrofishing, but the crew carried a dip net in case eulachon were observed to be spawning in large enough numbers for active capture.

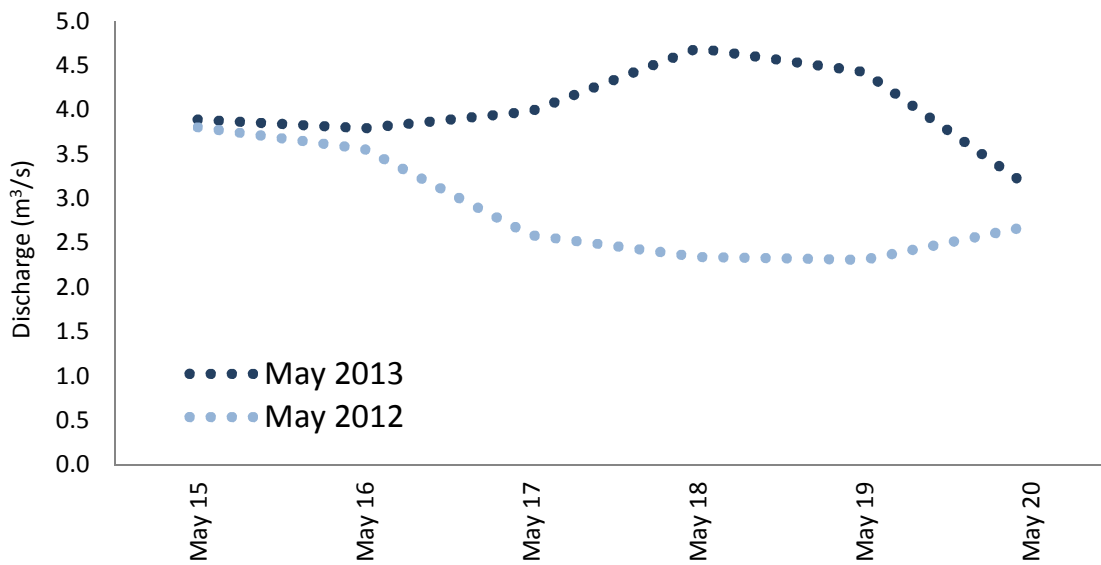
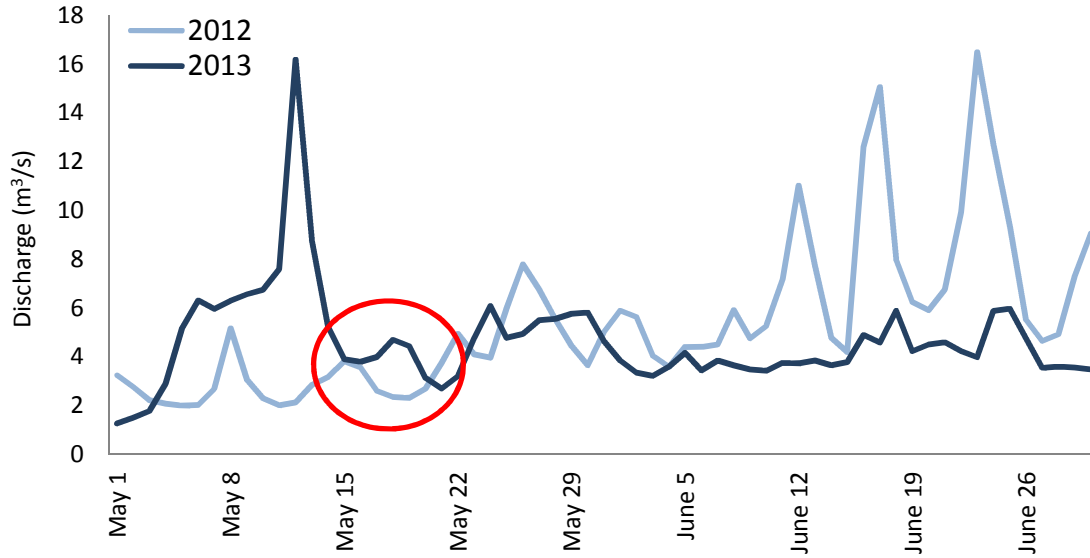
Previous reconnaissance trips examined the indistinct wetted area west of the Haul Road in the Lower Wetland Complex. South of Anderson Creek, an intermittent constructed side channel was observed draining into a wetland and eventually flowing through a culvert east under the Haul Road and into Anderson Creek mainstem. This area has been defined as the Anderson Creek South channel during the January survey (Appendix A, Figure A-3), but had not been previously examined for fish presence. A crew set minnow traps in both the beaver ponds and the constructed channel flowing from Anderson Creek to the north. Further north of Anderson Creek, the field crew set minnow traps in the Lower Wetland Complex west of the Haul Road, in several pools with no obvious surface connectivity to Anderson Creek, Beaver Creek, or the Anderson Creek North channel.

The remainder of the trapping efforts for March 2013 focused on several locations in the Upper and Lower Wetland Complexes extending off Beaver Creek, located upstream of BT2. Field crews set 50 Gee traps in the following areas:

- Lower Wetland Complex: off-channel habitats between BT2 and the Methanex rail spur culverts
- Upper Wetland Complex:
 - off-channel habitat on the north side of the Methanex culverts
 - off-channel habitat along mainstem Beaver Creek and east of Haisla Boulevard, and
 - large ponds to the north, but east of Haisla Boulevard (culvert area previously sampled in January).
- Eurocan Slough: north of the Upper Wetland Complex draining east into the Kitimat River.

May 2013

The final freshwater survey further examined the extent of usable off-channel habitats in the LSA. Hydrometric surveys in May and June 2012 and 2013 showed that the flow stage in May 2012 was reduced compared to May 2013, and elevated in June 2012 compared to June 2013 (Figure 4.1-1). The freshwater fish habitat survey crew mapped out side channel and off-channel habitat between May 17 and May 19, 2013, considering the wetted areas mapped out in the mainstem habitat during May and June 2012. This allowed for an estimation of habitat availability in terms of total wetted area and considered high water refuge (Millar et al. 1997) during the intermediate flow stages of stream discharges associated with spring freshet. Habitat mapping included measurement of total length and average wetted width of off-channel habitats, excluding wetlands.



NOTE: * Top figure shows data trends for May and June; red inset is enlarged in bottom figure to show data specific to the freshwater fish habitat sampling periods in May 2012 and 2013 (Source: Triton 2013).

Figure 4.1-1: Anderson Creek Discharge Based on Hydrometric Surveys*

Fish capture efforts during this trip specifically targeted potential fish habitat that had not been previously examined. These included:

- fish sampling in portions of the Upper Wetland Complex off Beaver Creek where traps had not previously been placed in March 2013
- fish sampling in a narrow channel below the Haul Road culverts of the Lower Wetland Complex draining into Beaver Creek from the west
- fish sampling in the remaining ponds in the Lower Wetland Complex west of the Haul Road culverts and north of Anderson Creek, and
- fish sampling in the wetland on the northwest end of the Dike Area near Beaver Creek.

4.1.1.3 Data Analysis

The total abundance of the combined catch as well as the total abundance by species in closed electrofishing sites has been considered using the two respective estimation procedures:

- likelihood estimate (Schnute 1983), and
- regression analysis (Leslie and Davis 1939).

Total Abundance – Likelihood Estimate

Schnute (1983) developed an approach that estimates N by minimizing the negative log likelihood of a two-parameter binomial model, which considers fish abundance N and catchability q . These parameters are estimated from the set of observed catches C_1, \dots, C_k across k passes, from which the total cumulative catch T_i up to and including each successive pass is obtained.

The likelihood can be evaluated over a range of hypothesized values for N . Schnute (1983) derived N by minimizing negative log likelihood of the predicted catch per pass over k passes and predicted total catch respectively, given the observed data.

Uncertainty in the likelihood estimate can then be determined with the likelihood ratio test (Hilborn and Mangel 1997) and evaluated in terms of the 95% confidence interval for the range of likelihoods. The lower end of the confidence interval is the total observed catch; however, the likelihood profile may not allow for calculation of an upper confidence limit when the catch data are inadequate. Consequently, this model has not been used to estimate N of component catch (i.e., abundance by species). These estimates have been derived using the regression model.

Abundance by Species – Regression Analysis

The regression model is a more simplistic analysis developed by Leslie and Davis (1939), which considers the depletion of fish in the closed site using a standardized amount of fishing effort in each pass (see Section 4.1.1.2 for details). Catch data are used to predict N given a constant q over

consecutive passes in the closed site. Generally speaking, the removal estimator is constructed using state and observation submodels (Walters and Martell 2004). The state model is as follows:

$$N_p = N - K_p$$

where N_p is the abundance of fish in the area during pass p and K_p is the total amount of fish removed before p (i.e., the cumulative catch) such that when $p = 0$, $K_p = 0$ and $N_p = N$. The observation submodel considers Y_p as an index of abundance at pass p :

$$Y_p = qN_p$$

Substitution of the state model into the observation model results in the linear function of the form $y = a + bx$:

$$Y_p = qN - qK_p$$

where the a term is intercept qN and the slope b is the negative value of q . The abundance index Y_p thus becomes dependent on the cumulative catch K_p and approaches 0 as K_p approaches N .

CPUE

Abundance estimation in closed sites is a useful means of understanding the distribution of fish in certain habitats, such as channel unit types in this study; however, the sampling procedures have limited application given the diversity of stream and off-channel habitats observed throughout the larger aquatic ecosystem. Distribution of fish throughout the LSA has also been evaluated using CPUE as an index of relative abundance. Open-site electrofishing and minnow trapping are the two capture methods considered (excluding the single dip netting event in Kitimat River West during the March 2013 survey). Effort expended in representative habitats throughout the LSA considers total catch as a rate of capture given a capture method m over the time period T :

$$CPUE_m = C_T / T_m$$

where C_T is total catch and T_m is the effort expended in total seconds for electrofishing and total hours for minnow trapping for each trap type (Gee traps and mesh traps).

4.1.2 Results

4.1.2.1 Freshwater Fish Habitat

Water Quality

Water quality parameters collected throughout the study are presented in Table 4.1-3. The scope was expanded to include reference conditions (Cecil Creek in June and September 2012), and additional wetted areas examined in the LSA in 2013. Additional water quality parameters collected from creeks and other peripheral wetted areas in 2013 are shown in Table 4.1-4.

Table 4.1-3: Basic Water Quality Parameters in the LSA

Location	Temperature (°C)		pH		Conductivity (µS/cm)		Turbidity
	mean	σ	mean	σ	mean	σ	median
May 2012							
Anderson Creek	3.0	0.2	7.3	0.1	12	1	C
Beaver Creek	6.1	1.0	7.2	0.2	47	17	C
Moore Creek ^a	10.8	–	7.1	–	642	–	L
June 2012							
Anderson Creek	7.1	1.1	7.7	0.3	4	2	L
Beaver Creek	5.7	0.2	6.9	0.1	10	–	M
Moore Creek ^a	8.4	0.5	7.5	0.3	154	45	M
Cecil Creek	8.4	–	7.1	–	9	–	C
September 2012							
Anderson Creek	10.8	0.7	7.5	0.4	23	2	C
Beaver Creek	11.7	2.2	7.1	0.3	45	31	L
Moore Creek	12.7	1.2	7.1	0.2	296	313	L
Cecil Creek	8.5	0.0	6.2	0.1	15	2	C
January 2013							
Anderson Creek	1.7	0.1	7.3	0.3	18	5	C
Beaver Creek	2.1	0.4	7.1	0.2	64	31	M
Wetland Complexes ^b	1.8	–	6.3	–	71	–	L
Moore Creek	2.8	1.3	7.0	0.2	70	64	C
March 2013							
Anderson Creek South ^c	1.1	0.2	7.1	0.4	29	8	–
Beaver Creek	2.4	1.4	7.1	0.2	70	28	L
Wetland Complexes ^b	1.1	1.3	7.7	–	145	111	L
Eurocan Slough	4.4	0.4	6.5	0.3	125	14	T
Dike Area	4.2	2.5	6.7	0.3	1,478	1,227	L
Kitimat River side channel ^d	2.1	–	7.3	–	43	–	–
Kitimat River oxbow ^d	4.3	0.8	6.4	0.6	99	50	T

Location	Temperature (°C)		pH		Conductivity (µS/cm)		Turbidity
	mean	σ	mean	σ	mean	σ	median
May 2013							
Anderson Creek	5.7	1.8	7.5	0.2	12	0	C
Anderson Creek East ^c	7.5	4.1	6.4	0.0	116	144	C
Beaver Creek	9.1	1.7	9.5	4.2	77	31	L
Beaver Creek side channels ^e	8.7	0.6	8.6	2.6	67	0	L
Moore Creek	7.5	3.7	7.7	0.2	13	3	–

NOTES:

^a Actually represents a slough off Lower Anderson Creek and a former Moore Creek side channel blocked by a dike

^b Both Upper and Lower Wetland Complexes

^c Off-channel habitat of Anderson Creek above the main Beaver Creek confluence

^d Located in Kitimat River West area (see Appendix A, Figure A-3)

^e Off-channel habitat in Beaver Creek below the Lower Wetland Complex

σ – standard deviation

C – clear, L – low, M – moderate, T – turbid

– no data collected

Table 4.1-4: Additional Water Quality Parameters in Wetted Areas – 2013

Location	DO (%)		DO (mg/L)		ORP (mV)		Salinity (‰)	
	mean	σ	mean	σ	mean	σ	mean	σ
March 2013								
Wetland Complexes ^a	–	–	5.14	1.51	–	–	–	–
Eurocan Slough	39.18	13.29	5.03	1.70	95.35	17.78	0.10	0.01
Dike Area	–	–	9.08	3.14	–	–	1.76	0.96
Kitimat River side channel ^b	88.10	–	12.40	–	131.50	–	0.03	–
Kitimat River oxbow ^b	–	–	5.14	1.51	–	–	–	–
May 2013								
Anderson Creek	104.15	0.78	13.05	0.68	80.15	32.46	0.01	0.00
Anderson Creek North	60.75	32.74	7.50	4.68	62.45	62.01	0.26	0.35
Beaver Creek	67.45	32.88	8.08	3.73	65.18	20.47	0.04	0.03
Beaver Creek side channels ^c	65.95	24.96	5.20	3.84	95.50	22.20	0.05	0.01
Upper Wetland Complex	–	–	2.61	0.45	–	–	–	–
Lower Wetland Complex	–	–	0.98	0.13	–	–	–	–
Moore Creek	100.90	2.97	12.17	1.46	47.25	39.39	0.01	0.00
Dike Area	83.45	0.49	9.75	0.28	62.35	2.47	0.03	0.02

NOTES:

^a Both Upper and Lower Wetland Complexes

^b Located in Kitimat River West area

^c Off-channel habitat in Beaver Creek below the Lower Wetland Complex

σ standard deviation

– no data were collected

Habitat Transects

Mainstem transect information has been analyzed according to season and stage of stream discharge, including:

- measurable channel and flow characteristics (Table 4.1-5)
- observed channel characteristics (Table 4.1-6)
- observed streambed characteristics (Table 4.1-7)
- observed cover characteristics (Table 4.1-8), and
- observed salmonid habitat quality during different life stages and activities (Table 4.1-9).

Table 4.1-5: Measurable Channel Dimensions, Flow Characteristics, and Water Quality Parameters based on Transect Data

Variable	Anderson Creek		Beaver Creek		Moore Creek		Cecil Creek	
	mean	σ	mean	σ	mean	σ	mean	σ
May 2012								
Discharge (m ³ /s)	2.84	0.99	0.59	0.25	–	–	–	–
Cross-sectional area (m ²)	6.70	2.61	2.95	1.58	3.61	1.42	–	–
Channel width (m)	16.4	6.4	10.2	5.4	9.3	3.8	–	–
Wetted width (m)	15.4	5.2	7.3	2.9	8.6	4.4	–	–
Residual pool depth (m)	1.15	0.49	–	–	–	–	–	–
Bankfull depth (m)	1.11	0.23	1.26	0.71	0.98	0.25	–	–
Temperature (°C)	3.0	0.2	6.2	1.1	10.8	–	–	–
Conductivity (µS/cm)	12	1	50	20	642	–	–	–
pH	7.3	0.1	7.2	0.1	7.1	–	–	–
June 2012								
Discharge (m ³ /s)	4.94	1.63	1.68	1.29	–	–	0.27	0.09
Cross-sectional area (m ²)	8.70	3.76	3.32	2.45	3.51	2.60	1.45	1.03
Channel width (m)	16.3	4.8	9.6	4.7	8.2	4.2	6.9	2.0
Wetted width (m)	15.9	5.3	8.5	3.5	7.4	3.9	5.4	1.2
Residual pool depth (m)	1.12	0.54	–	–	0.53	–	0.56	0.04
Bankfull depth (m)	1.59	0.41	1.00	0.38	0.85	0.28	0.69	0.21
Temperature (°C)	7.7	0.4	7.4	1.8	8.4	0.5	8.4	–
Conductivity (µS)	3	2	23	19	304	257	9	–
pH	7.8	0.5	7.2	0.2	–	–	7.1	–
September 2012								
Discharge (m ³ /s)	0.43	0.30	0.10	0.11	0.02	0.04	0.00	0.00
Cross-sectional area (m ²)	3.72	2.47	1.83	1.82	1.42	1.69	0.00	0.00
Channel width (m)	17.2	6.5	10.7	5.9	10.1	2.8	6.6	2.1
Wetted width (m)	14.0	4.5	8.3	3.3	7.6	2.5	2.9	1.1
Residual pool depth (m)	0.79	0.66	0.30	0.15	0.90	0.64	0.37	0.11

Variable	Anderson Creek		Beaver Creek		Moore Creek		Cecil Creek	
	mean	σ	mean	σ	mean	σ	mean	σ
Bankfull depth (m)	1.78	0.32	1.00	0.46	1.15	0.72	1.08	0.60
Temperature (°C)	11.0	0.7	11.7	2.2	12.7	1.2	8.5	0.0
Conductivity ($\mu\text{S}/\text{cm}$)	24	2	45	31	296	313	15	2
pH	7.4	0.4	7.1	0.3	7.0	0.3	6.2	0.1
January 2013								
Discharge (m^3/s)	2.29	1.04	0.45	0.05	1.48	0.36	–	–
Cross-sectional area (m^2)	6.53	3.34	2.53	0.22	4.34	3.27	–	–
Channel width (m)	15.4	5.6	8.3	6.5	11.1	3.4	–	–
Wetted width (m)	14.6	5.9	8.7	6.3	8.7	2.5	–	–
Residual pool depth (m)	0.75	0.50	0.40	–	1.35	–	–	–
Bankfull depth (m)	1.57	0.48	0.88	0.43	1.29	0.98	–	–
Temperature (°C)	1.7	0.0	2.3	0.4	2.1	0.0	–	–
Conductivity ($\mu\text{S}/\text{cm}$)	17	1	63	13	39	9	–	–
pH	7.3	0.3	7.0	0.2	7.1	0.0	–	–
March 2013								
Discharge (m^3/s)	0.92	0.11	0.41	0.21	–	–	–	–
Cross-sectional area (m^2)	5.25	3.10	2.16	1.44	–	–	–	–
Channel width (m)	–	–	5.20	–	–	–	–	–
Wetted width (m)	–	–	4.30	–	–	–	–	–
Residual pool depth (m)	–	–	–	–	–	–	–	–
Bankfull depth (m)	–	–	1.35	–	–	–	–	–
Temperature (°C)	–	–	2.8	–	–	–	–	–
Conductivity ($\mu\text{S}/\text{cm}$)	–	–	91	–	–	–	–	–
pH	–	–	7.3	–	–	–	–	–

NOTES:

σ standard deviation
– no data collected

Table 4.1-6: Observed Channel Characteristics based on Transect Data

Characteristic	Anderson Creek	Beaver Creek	Moore Creek	Cecil Creek
Pattern	Irregular, wandering	Irregular meandering	Sinuuous	Irregular meandering
Islands	Occasional		None	
Bars	Side	None		
Coupling	Decoupled			
Confinement	Unconfined			
Bank shape	Vertical		Vertical/sloping	
Bank texture	Gravels	Fines	Fines	Gravels
Riparian vegetation	Coniferous	Mixed	Grass/shrub	Mixed

Table 4.1-7: Observed Bed Material by Season based on Transect Data

Characteristic	Anderson Creek				Beaver Creek					Moore Creek		Cecil Creek	
	May	Jun	Sep	Jan	May	Jun	Sep	Jan	Mar	Sep	Jan	Jun	Sep
% Organic	0	0	5	0	10	10	15	20	35	0	0	0	5
% Fine	15	20	10	10	30	30	30	25	35	40	25	10	10
% Small gravel	20	20	15	30	30	30	15	20	20	30	30	20	20
% Large gravel	30	30	25	40	20	20	20	30	10	20	35	30	25
% Small cobble	30	20	25	15	10	10	15	5	0	15	10	25	25
% Large cobble	5	10	20	5	0	0	5	0	0	5	0	15	15
% Boulder	0	0	0	0	0	0	0	0	0	0	0	0	0
% Bedrock	0	0	0	0	0	0	0	0	0	0	0	0	0
Embedded?	No				Yes					Yes		No	Yes

Table 4.1-8: Observed Cover Characteristics by Season based on Transect Data

Characteristic	Anderson Creek				Beaver Creek					Moore Creek		Cecil Creek		
	May	Jun	Sep	Jan	May	Jun	Sep	Jan	Mar	Sep	Jan	Jun	Sep	
Cover Characteristics														
Total cover	Moderate				A					M	Trace		Moderate	
Dominant cover	OV			U	LWD					U	LWD	OV		
Subdominant cover	LWD				OV	IV	U		IV	LWD	SWD	LWD	U	
Crown closure	21 – 40%			0 – 20%	21 – 40%					0 – 20%		21 – 40%		
Functional LWD	Moderate				Abundant					Trace				
LWD Distribution	Clumped				Even					Clumped		Even		

NOTES:

OV – overstream vegetation, IV – instream vegetation, U – undercut, SWD – small woody debris, LWD – large woody debris, M – moderate, A – abundant

Table 4.1-9: Seasonal Ranking of Salmonid Habitat in Mainstem Channels

Fish Use	Anderson Creek				Beaver Creek					Moore Creek		Cecil Creek	
	May	Jun	Sep	Jan	May	Jun	Sep	Jan	Mar	Sep	Jan	Jun	Sep
Salmonid Habitat													
Spawning	–	M	E	–	–	P	P	–	M	P	–	P	P
Rearing	M	P	M	M	G	M	E	G	G	M	G	G	P
Overwintering	–	–	M	M	–	–	G	G	G	M	M	–	P
Migration	G	G	M	G	M	M	P	P	M	G	G	M	P
Staging/holding	G	G	G	M	M	M	G	M	G	G	M	M	P

NOTE:

P – poor, M – moderate, G – good, E – excellent
 – no sampling occurred

Mainstem Habitat

Mainstem Level 1 FHAP data are described for each stream in the LSA. The Anderson Creek and Beaver Creek mainstems extend from the confluence to the uppermost transect (Site AT1) on Anderson Creek and Site BT2 on Beaver Creek, directly below the Lower Wetland Complex. Site BT1 was established in January 2013 upstream of these wetland habitats on Beaver Creek, where the mainstem resumes as a single channel. Appendix C, Table C-1, lists the dimensions and wetted area of all mainstem channel units in Anderson and Beaver creeks for all seasons examined. Table 4.1-10 shows the seasonal total wetted areas for the Anderson Creek and Beaver Creek mainstems in terms of channel unit type (Figure 4.1-2).

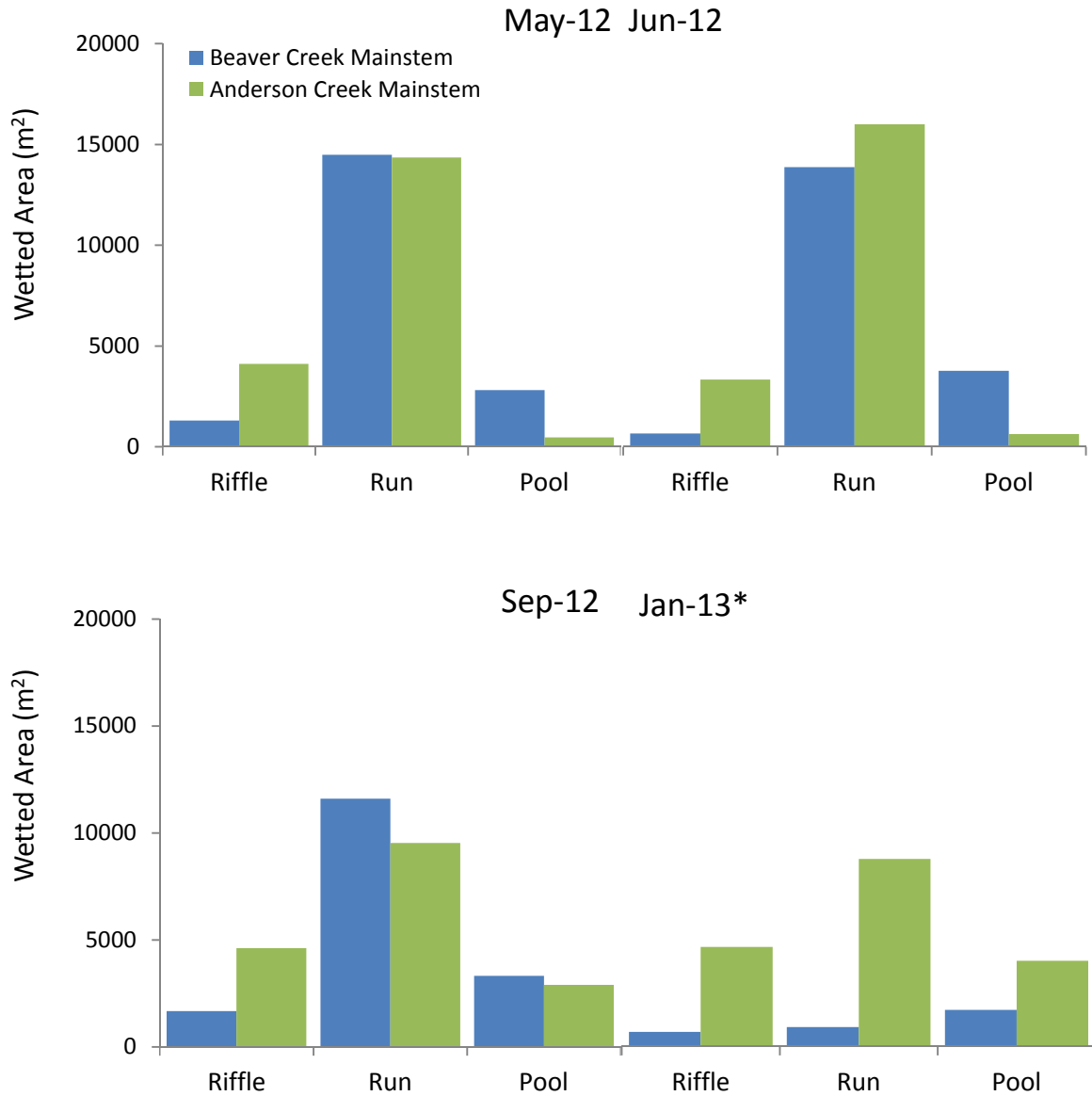
A section has also been described for Moore Creek upstream from the estuary and into the reach west of the Haul Road. Table 4.1-11 provides a reach-wise description of the channel characteristics in the mainstem of each respective stream included in the LSA.

Table 4.1-10: Total Wetted Area by Channel Unit Type in Mainstem Channels

Stream	Riffle (m ²)	Run (m ²)	Pool (m ²)	Total Wetted Area (m ²)
May 2012				
Anderson Creek	4,108	14,347	473	18,928
Beaver Creek	1,303	14,483	2,812	18,597
June 2012				
Anderson Creek	3,330	16,005	636	19,972
Beaver Creek	669	13,878	3,770	18,317
September 2012				
Anderson Creek	4,613	9,536	2,905	17,054
Beaver Creek	1,680	11,601	3,326	16,608
January 2013				
Anderson Creek	4,663	8,793	4,011	17,468
Beaver Creek	–	–	–	–

NOTE:

– Beaver Creek data for January 2013 are incomplete.



NOTE: * Beaver Creek data are incomplete for January 2013.

Figure 4.1-2: Relative Amount of Channel Units for Total Wetted Area Estimates

Table 4.1-11: Mainstem Channel Characteristics

Reach	Gradient	Channel Width (m)		Bankfull Depth (m)		Max. Pool Depth (m)		Residual Pool Depth (m)		Bed Material	
		mean	σ	mean	σ	mean	σ	mean	σ	Dom.	Subdom.
Anderson Creek											
1	1%	19.2	6.1	1.2	0.5	1.3	0.3	1.0	0.3	G	S
2	1%	17.4	5.1	1.3	0.5	1.3	0.3	1.0	0.4	G	S
3	2%	17.4	13.6	1.1	0.3	1.1	0.1	0.8	0.2	G	S
4	1%	22.3	2.4	1.2	0.6	1.7	0.2	1.4	0.2	G	C
Beaver Creek											
1	<1%	14.4	2.1	1.6	0.4	–	–	–	–	S	G
2	<1%	17.8	7.6	1.2	0.2	1.9	0.3	–	–	S	G
3	<1%	–	–	–	–	>2	–	>2	–	S	G
Moore Creek											
1	<1%	11.0	2.8	–	–	–	–	–	–	S	G
2	1%	14.1	5.0	1.5	0.6	1.5	0.6	1.1	0.6	G	S

NOTE:

C – cobbles, G – gravels, S – sands, silts, and other fine sediments
 σ standard deviation
 – no data collected

Off-channel Habitat

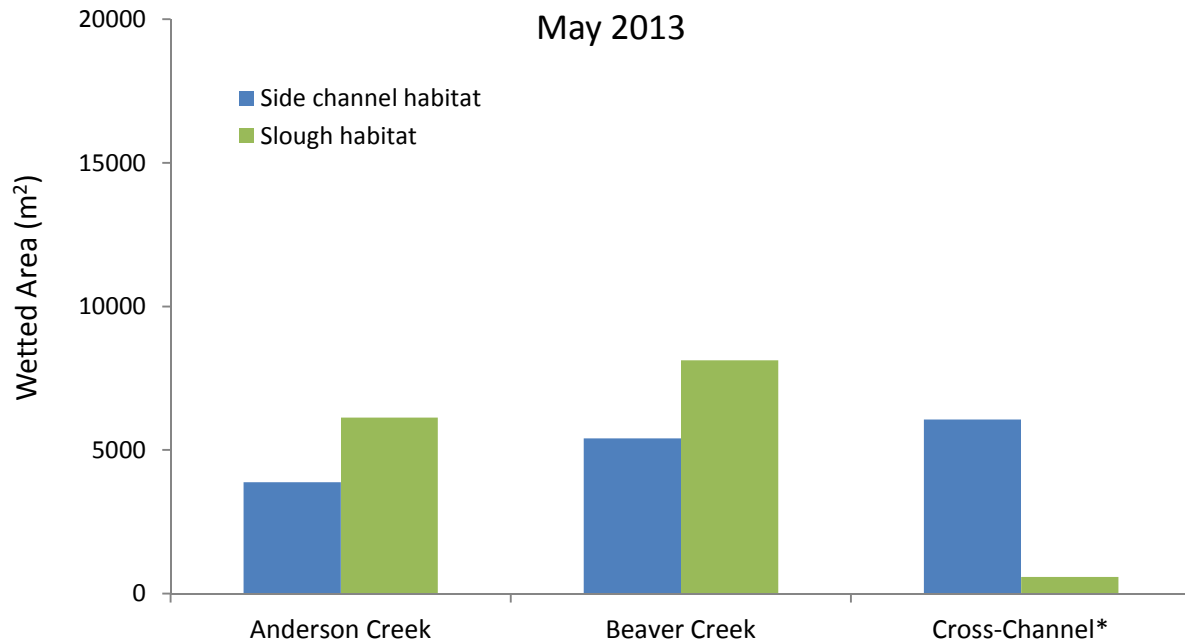
Significant off-channel habitats exist in the LSA, particularly along the lower reaches of Anderson and Beaver creeks. Off-channel habitats have been classified according to Johnston and Slaney (1996) as either side channels, with entry and exit points into mainstem streams, or sloughs, which have a blind end upstream that drains into a mainstem channel. The upstream end has either a groundwater source or an ephemeral surface flow at higher stages of stream discharge. In the case of Anderson and Beaver creeks, there is also a degree of cross-channel habitat (i.e., flows that exit Anderson Creek and enter Beaver Creek upstream of the main confluence). The total wetted areas estimated in May 2013 for each type of off-channel habitat have been included in Table 4.1-12. Figure 4.1-3 shows the areal off-channel habitat in Anderson and Beaver creeks and cross-channel habitat in Anderson Creek North and Anderson Creek East on the mapping efforts in May 2013.

Table 4.1-12: Total Wetted Area of Off-channel Habitats – May 2013

Stream	Side Channels (m ²)	Sloughs (m ²)	Total (m ²)
Anderson Creek	2,466	7,687	10,152
Beaver Creek	5,402	8,122	13,524
Anderson-Beaver cross-channel ^a	6,057	432	6,489
Grand total off-channel habitat	13,925	16,241	30,165

NOTE:

^a Consists of wetted areas in Anderson Creek North and Anderson Creek East location areas



NOTE: * Includes all wetted habitat in Anderson Creek North and Anderson Creek East location areas.

Figure 4.1-3: Relative Amount of Wetted Off-Channel Habitat* – May 2013

4.1.2.2 Freshwater Fish

Appendix C, Table C-2, lists the total effort and catch given the capture method used at each sample site in the LSA. Results are summarized by the capture methods employed and cite the results across locations and seasons.

Closed-site Electrofishing

Estimates of total abundance (N) involved two modelling approaches that used the three-pass removal capture method in closed sites; both models assumed a constant q among passes. Table 4.1-13 displays the estimated total N and q with 95% confidence intervals based on the likelihood approach developed by Schnute (1983). Species per site was estimated from depletion regressions of the catch composition (Leslie and Davis 1939; Walters and Martell 2004). Results have been displayed in Table 4.1-14 and include parameter estimates for N and q as well as R^2 values that assess model fit. Figure 4.1-4 displays the relative abundances for total catch (i.e., combined species) in all closed sites. Figure 4.1-5 to Figure 4.1-8 show the results of both modelling approaches for Anderson, Beaver, Moore, and Cecil creeks.

Table 4.1-13: Total Abundance N and CUPA Likelihood Estimates for each Season

Site	Channel Unit	Season	N	q	95% CI	CUPA (fish/m ²)
AEF-1-1	RN	Sep 2012	30	0.56	29 – 48	0.81
AEF-1-1	RF	Sep 2012	10	0.56	10 – 18	0.27
AEF-1-2 ^a	RN	Jun 2012	0	–	–	0
BEF-1-1	RF/RN	May 2012	18	0.49	17 – infinite ^b	0.14
BEF-1-2	RF/RN	Jun 2012	34	0.64	37 – 47	0.26
MEF-1-1	RF	Sep 2012	11	0.71	11 – 13	0.33
MEF-1-2	RN	Sep 2012	47	0.77	47 – 49	1.41
CEF-1-1	RN	Jun 2012	36	0.41	36 – 203	0.45
CEF-1-2	RF	Sep 2012	34	0.64	34 – 44	1.70

NOTES:

Data are calculated given constant catchability q across passes in closed electrofishing sites.

^a No fish captured at site

^b Indicates an upper confidence interval could not be determined by the model

AEF – Anderson Creek, BEF – Beaver Creek, MEF – Moore Creek, CEF – Cecil Creek, CI – confidence interval

RF – riffle, RN – run

Table 4.1-14: Estimated Catchability (q) and Abundance (N) by Species for each Season

Site	Season	Species	q	N	R^2	CPUA (fish/m ²)
Anderson Creek						
AEF-1-1	Sep-12	CO	0.56	19	0.90	0.51
		CAL	0.50	9	0.75	0.25
		CAS	1.00	1	1.00 ^a	0.03
		RB	0.50	1	0.25	0.03
AEF-1-2	Jun-12	CO	0.50	5	0.75	0.13
		CAL	0.58	6	0.91	0.15
Beaver Creek						
BEF-1-1	May-12	CO	0.36	18	0.89	0.14
		TSB	0.50	2	0.25	0.02
		L	1.00	1	1.00 ^a	0.01
BEF-1-2	Jun-12	CO	0.92	22	1.00	0.17
		TSB	0.23	16	0.30	0.12
		L	0.23	6	0.23	0.05
		CAL	1.00	1	1.00 ^a	0.01
Moore Creek						
MEF-1-1	Sep-12	CO	1.00	2	1.00 ^a	0.06
		CAL	0.86	8	1.00 ^a	0.25
MEF-1-2	Sep-12	CO	0.82	24	0.99	0.72
		CAL	0.81	21	1.00	0.63
		SFL	1.00	1	1.00 ^a	0.03
		RB	1.00	1	1.00 ^a	0.03
		TSB	1.00	1	1.00 ^a	0.03
Cecil Creek						
CEF-1-1	Jun-12	CT	0.33	34	0.32	0.34
		DV	0.75	3	0.75	0.04
		CO	1.00	2	1.00 ^a	0.03
CEF-1-2	Sep-12	CT	0.45	31	1.00	1.56
		CO	1.00	7	1.00 ^a	0.35

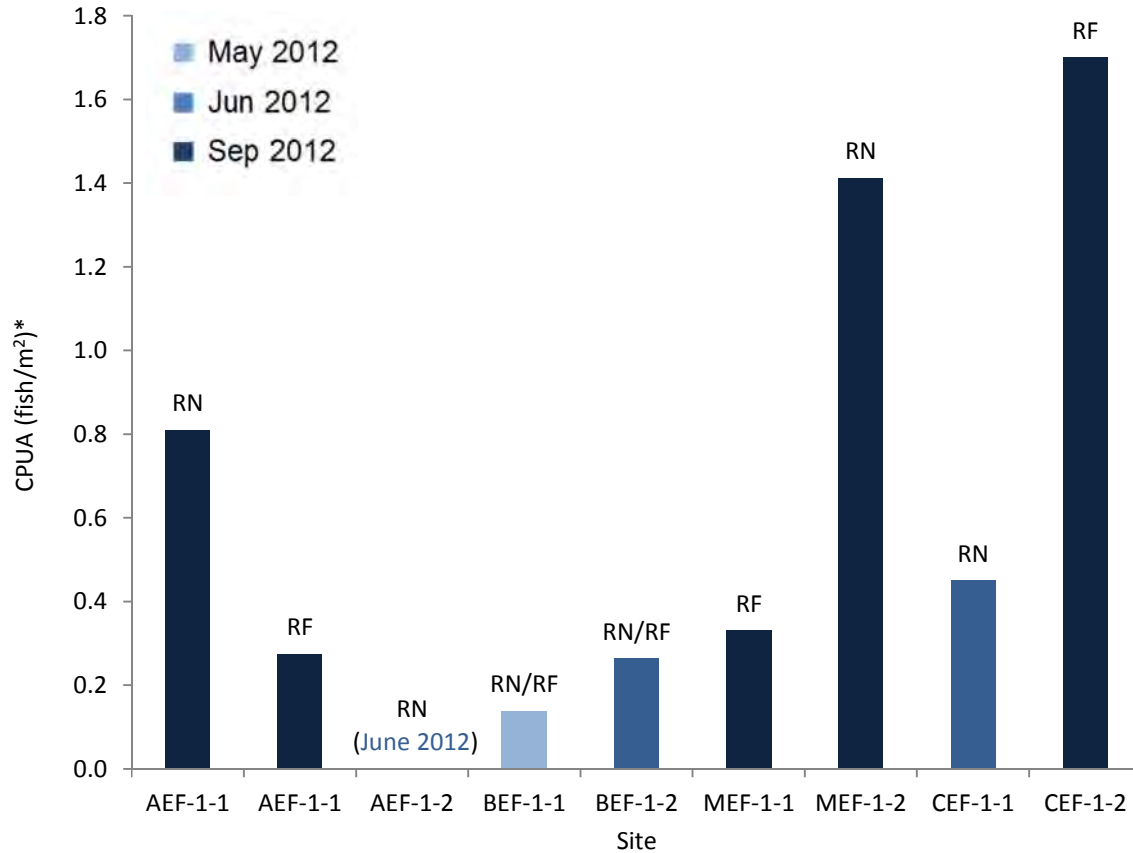
NOTES:

Data are based on regression analyses for all closed sites

^a Does not give a credible assessment of model fit because R^2 value is based on two data points only

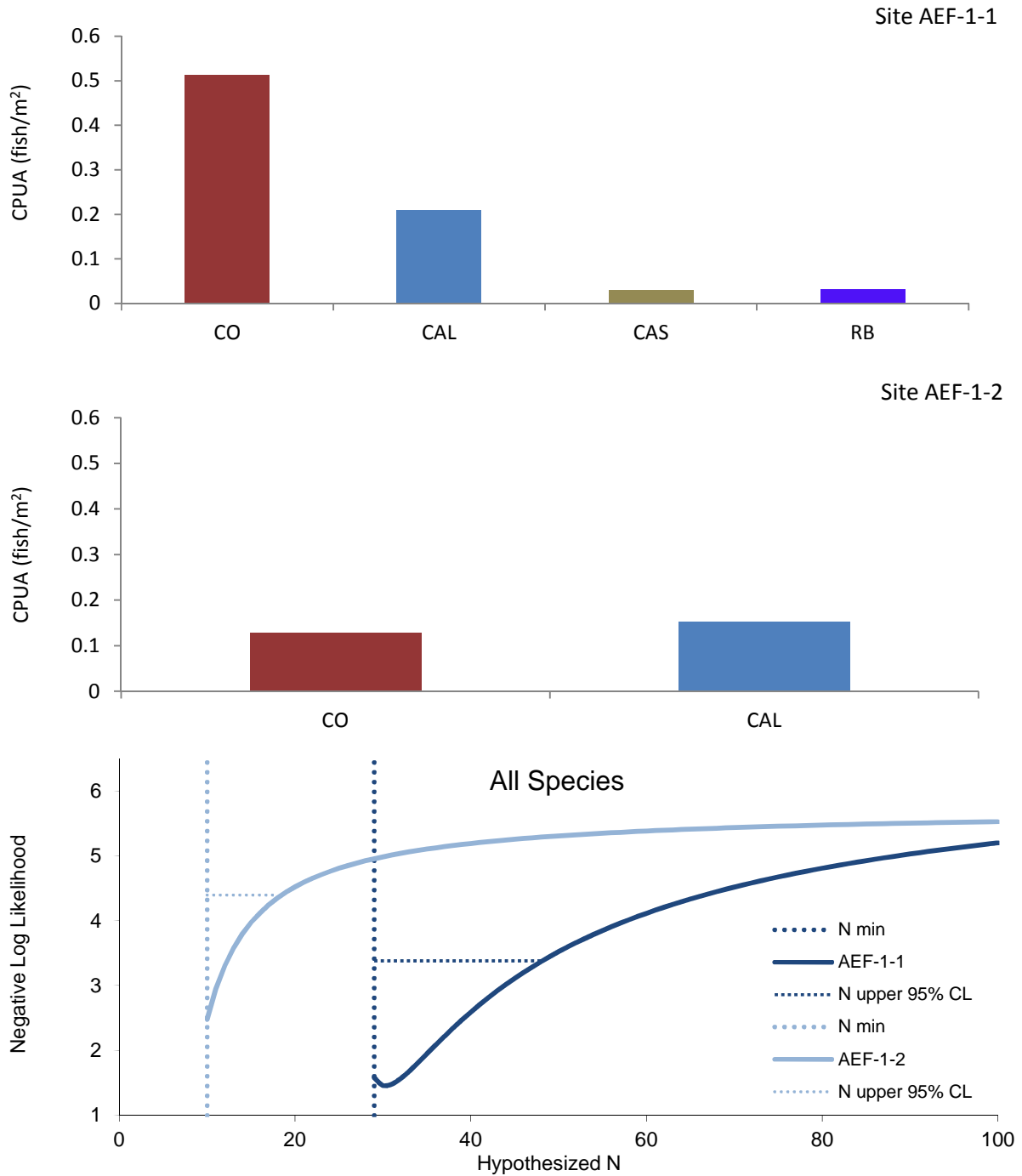
CO – coho, CAL – coastrange sculpin, CAS – prickly sculpin, RB – rainbow trout, TSB – threespine stickleback,

L – lamprey, SFL – starry flounder, CT – cutthroat trout, DV – Dolly Varden



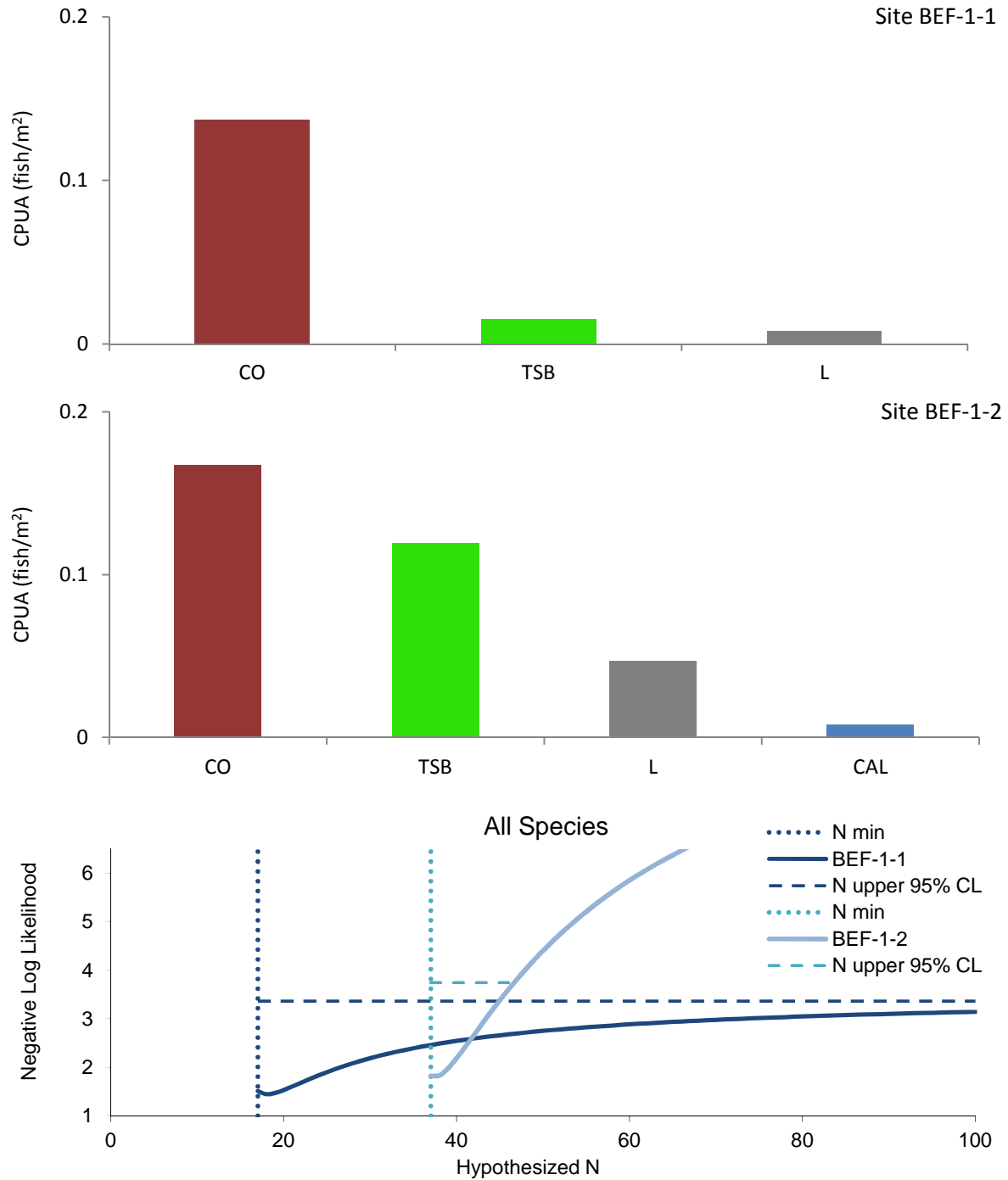
NOTES: * Given the minimum negative log likelihood and channel unit type during each season
 RF – riffle, RN – run

Figure 4.1-4: Estimated Total Fish Density (CPUA) for Closed Electrofishing Sites*



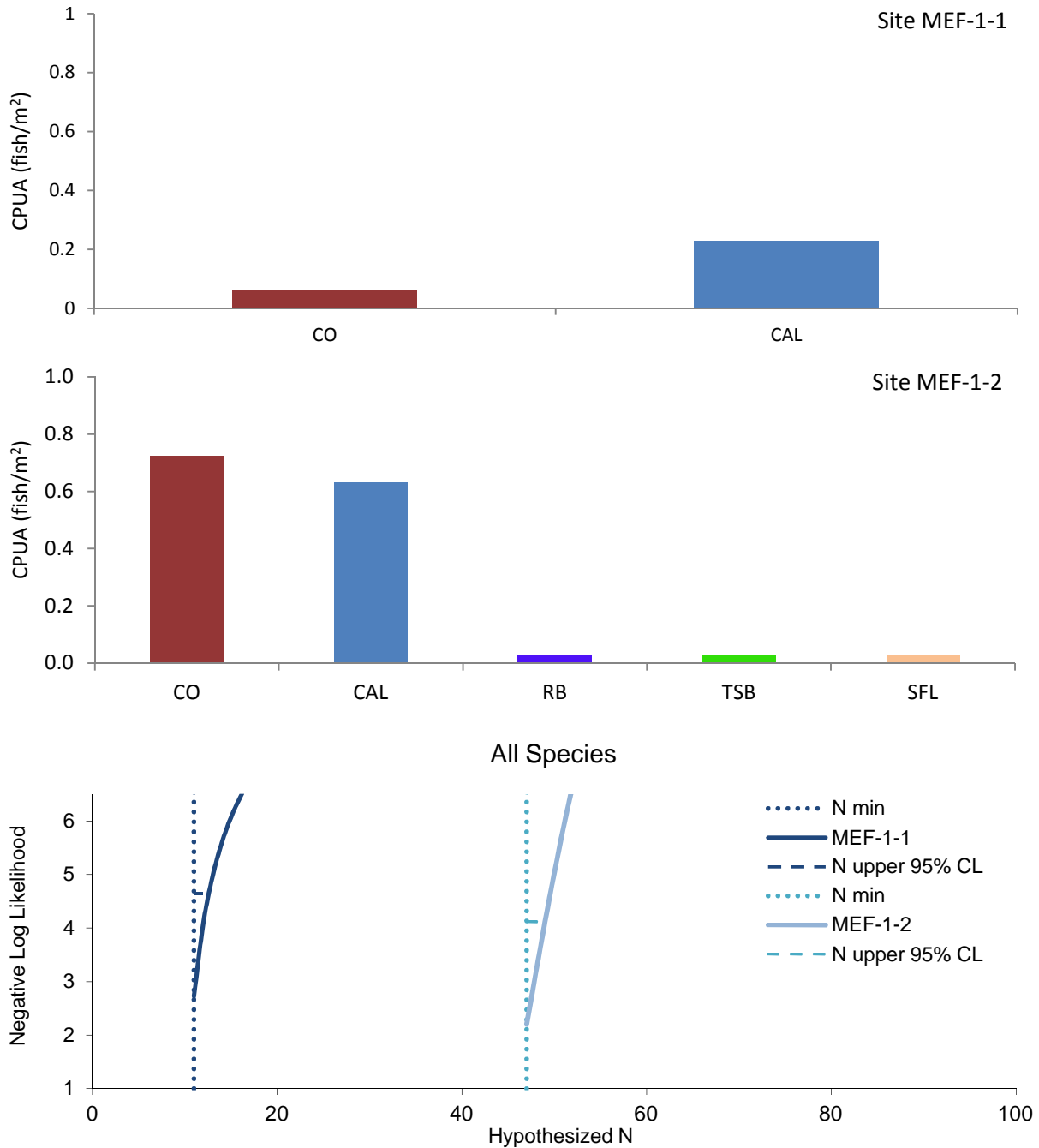
NOTES: * Closed sites. Bottom figure shows total abundance for combined species.
 CO – coho, CAL – coastrange sculpin, CAS – prickly sculpin, RB – rainbow trout

Figure 4.1-5: Electrofishing Removal CPUA Estimates by Species in Anderson Creek*



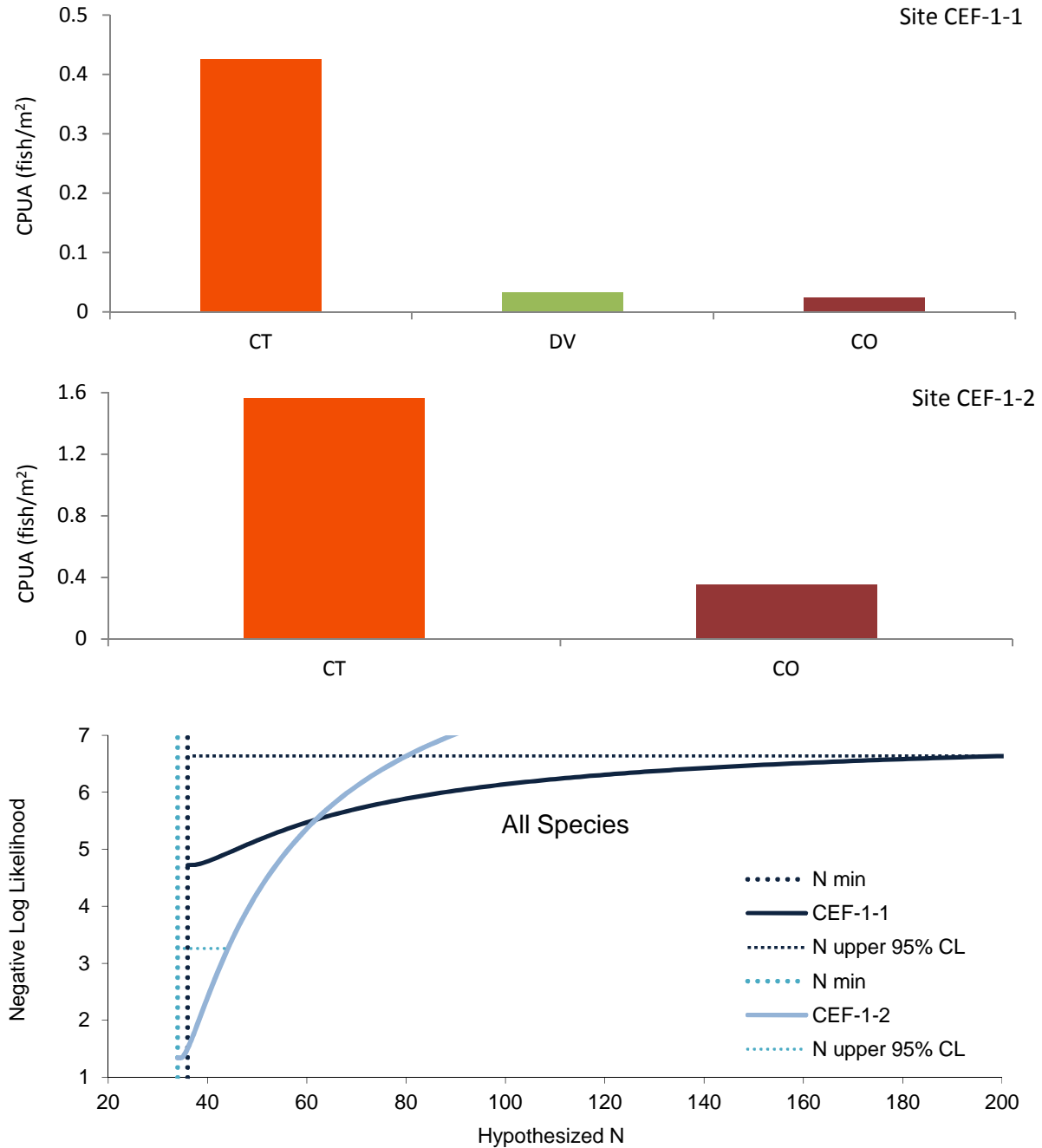
NOTES: * Closed sites. Bottom figure shows total abundance for combined species.
 CO – coho, TSB – threespine stickleback, L – lamprey, CAL – coastrange sculpin

Figure 4.1-6: Electrofishing Removal CPUA Estimates by Species in Beaver Creek*



NOTES: * Closed sites. Bottom figure shows total abundance for combined species.
 CO – coho, CAL – coastrange sculpin, RB – rainbow trout, TSB – threespine stickleback, SFL – starry flounder

Figure 4.1-7: Electrofishing Removal CPUA Estimates by Species in Moore Creek*



NOTES: * Closed sites. Bottom figure shows total abundance for combined species.
 CT – cutthroat trout, DV – Dolly Varden, CO – coho

Figure 4.1-8: Electrofishing Removal CPUA Estimates by Species in Cecil Creek*

Open-site Electrofishing

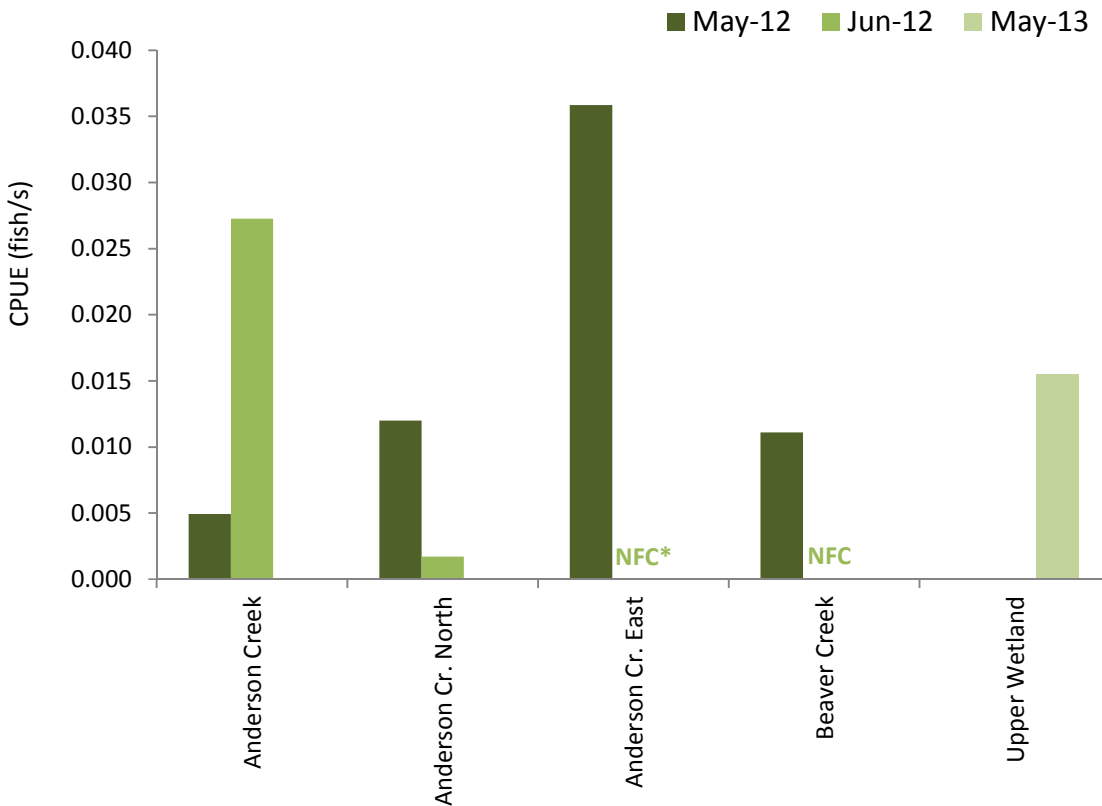
Open site electrofishing procedures during May 2012, June 2012, and May 2013 visits examined fish presence in terms of CPUE (i.e., fish captured per EF second) for mainstem channels and some off-channel habitats (i.e., Anderson Creek North, Anderson Creek East, and Upper Wetland Complex) in the LSA. Results between seasons are provided in Table 4.1-15 and Figure 4.1-9.

Table 4.1-15: Mainstem and Off-channel CPUE for Open Sites

Location	Site	May 2012 CPUE ^a	June 2012 CPUE ^a	May 2013 CPUE ^a
Anderson Creek	AEF-1-1	0.005	0.027	–
Anderson Creek North	ANCEF-1	0.012	0.002	–
Anderson Creek East	BEF-2-2	0.036	0	–
Beaver Creek	BEF-2-1	0.011	0	–
Upper Wetland Complex	BEF-3-2	–	–	0.015

NOTE:

^a CPUE measured in fish per second
 – no electrofishing data collected



NOTE: * NFC – no fish captured.

Figure 4.1-9: Calculated CPUE for all Open-site Electrofishing

Open-site Minnow Trapping

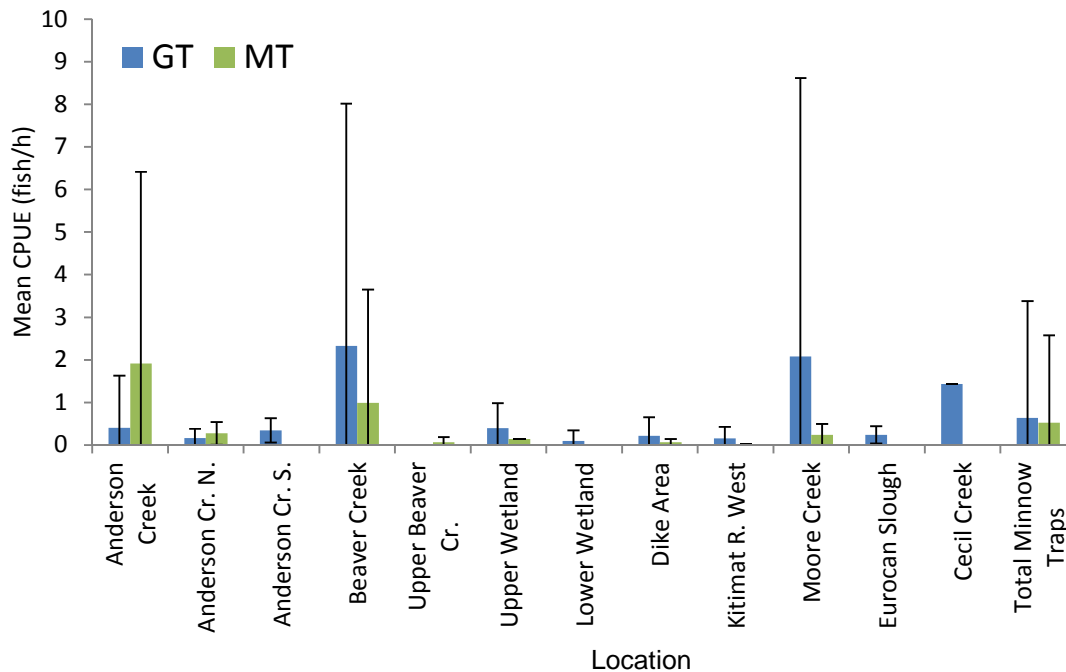
Minnow trapping was the dominant method of fish capture for this study. It allowed for effective fish sampling in all seasons throughout the LSA. Results for all species combined are summarized by location in Table 4.1-16. Figure 4.1-10 to Figure 4.1-13 display the results across species. Appendix C, Table C-3, lists CPUE by location for all species observed in the LSA.

Table 4.1-16: Total CPUE (Fish/hour) for Combined Species based on Minnow Trapping

Location	CPUE for Gee Traps			CPUE for Mesh Traps		
	n	mean	σ	n	mean	σ
Anderson Creek	73	0.41	1.22	16	1.92	4.50
Anderson Creek North	20	0.16	0.22	22	0.28	0.27
Anderson Creek South	13	0.34	0.29	0	ND	–
Beaver Creek	29	2.33	5.69	24	0.99	2.66
Upper Beaver Creek.	0	ND	–	43	0.07	0.12
Upper Wetland Complex	42	0.39	0.59	1	0.14	–
Lower Wetland Complex	50	0.10	0.25	0	ND	–
Dike Area	16	0.22	0.43	3	0.07	0.07
Kitimat River West	9	0.16	0.27	8	0.01	0.02
Moore Creek	23	2.08	6.54	8	0.24	0.26
Eurocan Slough	10	0.24	0.21	0	ND	–
Cecil Creek	1	1.43	–	0	ND	–

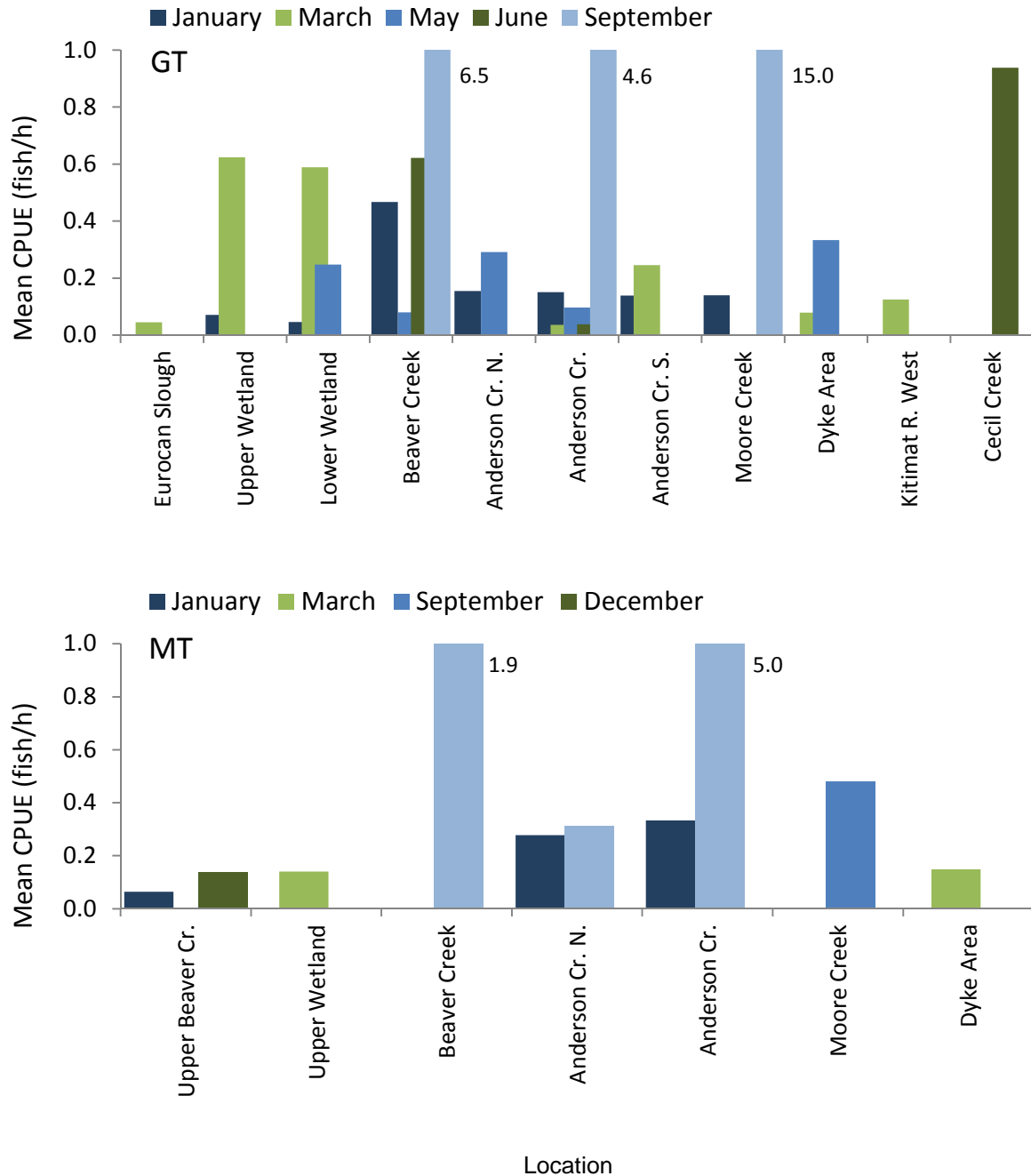
NOTE:

n – number of traps set in location area
 σ – standard deviation
 ND – no data



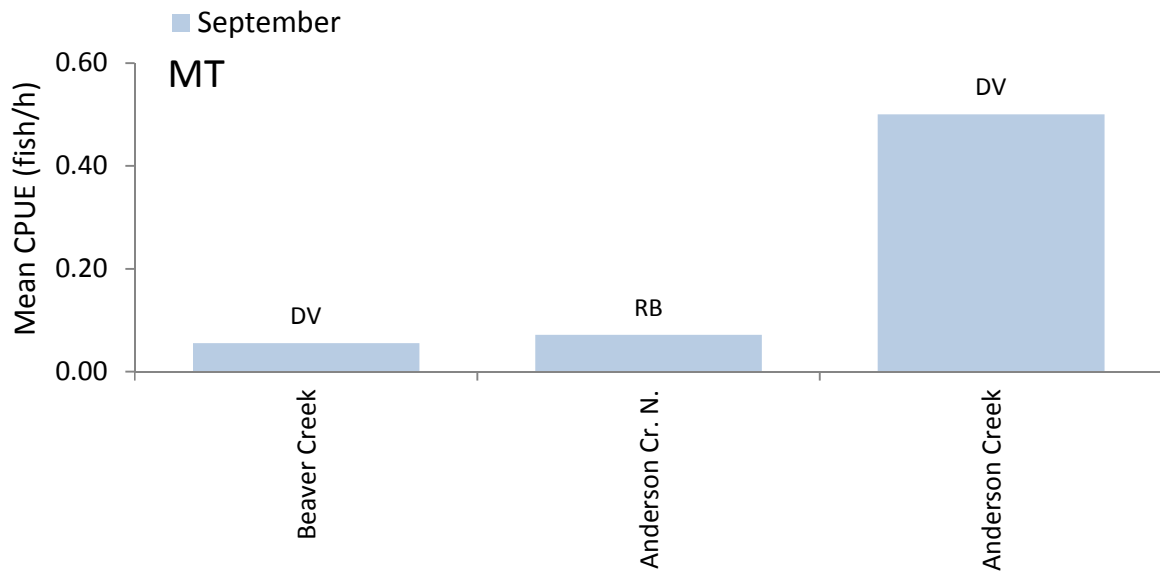
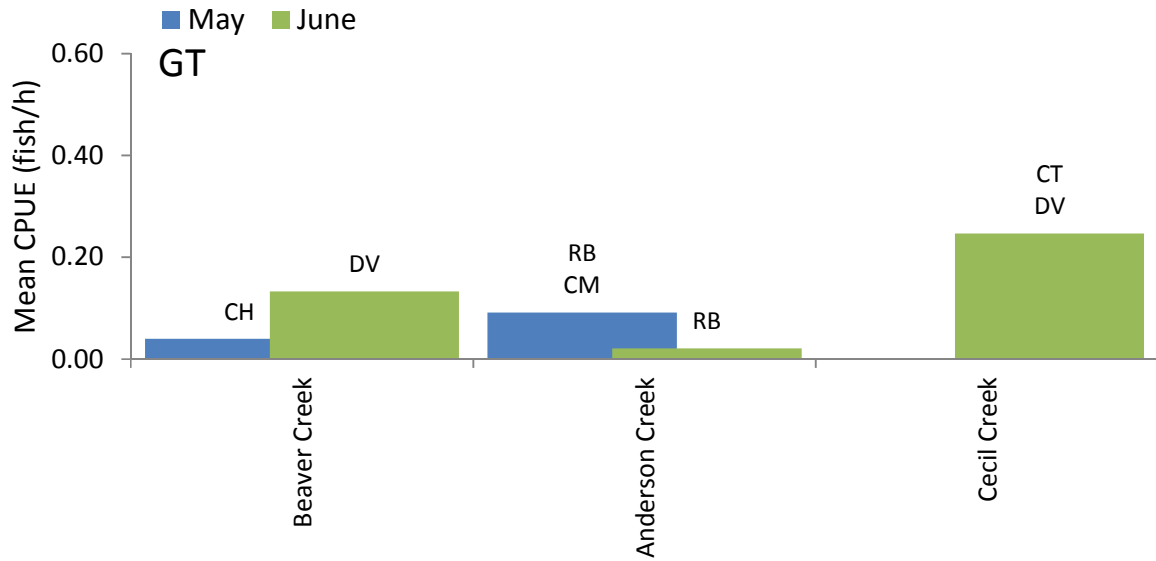
NOTE: * GT = Gee traps; MT = mesh traps

Figure 4.1-10: Combined CPUE for all Species Expressed as Means and Standard Deviations



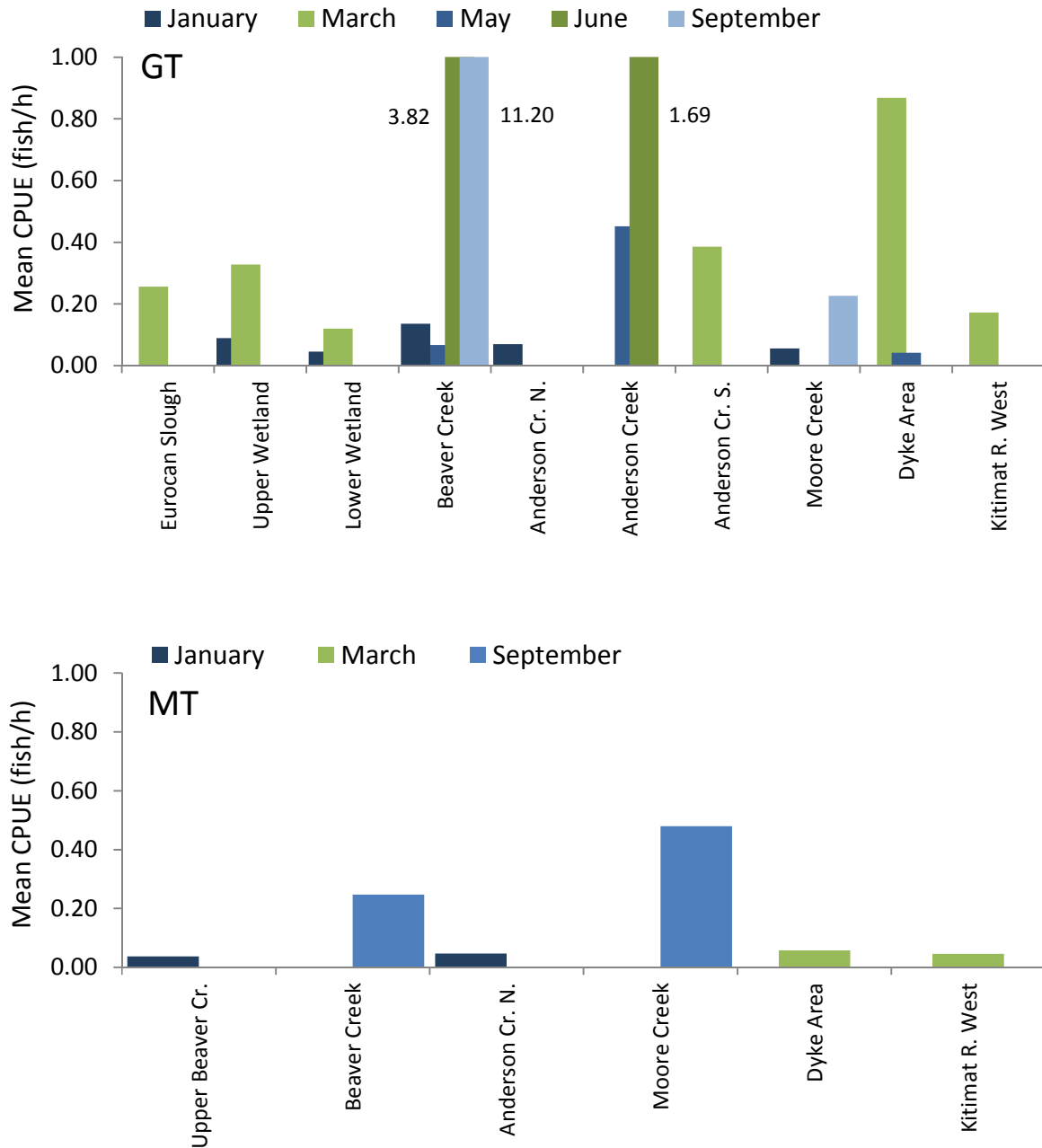
NOTE: * GT = Gee traps; MT = mesh traps

Figure 4.1-11: Seasonal Catch Distribution for CO Expressed as Mean CPUE*



NOTE: * GT = Gee traps; MT = mesh traps

Figure 4.1-12: Seasonal Catch Distribution for other Salmonids Expressed as Mean CPUE*



NOTE: * GT = Gee traps; MT = mesh traps

Figure 4.1-13: Seasonal Catch Distribution for TSB Expressed as Mean CPUE*

Dip Netting

The only instance of dip netting occurred during the March 2012 trip into Kitimat River West to look for eulachon. Eulachon were not observed in the oxbows or side channel; however, numerous chum salmon fry were observed and captured in the oxbow (Table 4.1-17).

Table 4.1-17: Chum Salmon Fry Captured by Dipnet in the Kitimat River Oxbow

Length (mm)	Weight (g)
38	0.4
36	0.4
38	0.4
39	0.4
37	0.5
40	0.6
36	0.4
38	0.4
44	0.7
48	1.2

4.1.3 Discussion

4.1.3.1 Freshwater Fish Habitat

A general description of the freshwater fish habitat is provided in this section on a reach-by-reach basis for Anderson, Beaver, and Moore creeks. Description and discussion of fish habitat also includes the Kitimat River West location area and the control site at Cecil Creek. General habitat photos have been included in Appendix E.

Anderson Creek Reach Descriptions

Anderson Creek is the principal tributary of the Kitimat River in the LSA. It does not flow directly into the Kitimat River mainstem; rather, it joins a series of estuarine channels immediately to the west. A previously constructed dike approximately 2 km long extends northwest from the estuary on the west side of the Kitimat River. The dike was initially constructed by Alcan in the 1950s as a Kitimat River flood and erosion control measure for the existing aluminum facility. The Dike Area has directly cut off surface flow into Anderson Creek from at least two large Kitimat River side channels (9U 520953 5985429 and 9U 521587 5985179). This has created large pool habitats directly east of the dike and shallow, tidally influenced sloughs that extend off Anderson Creek on the downstream side. The upper slough is directly

downstream of the confluence of Beaver and Anderson creeks. For classification purposes in this TDR, Reach 1 of Anderson Creek has been designated to start at its confluence with Beaver Creek.

Reach 1 extends 350 m through mature coniferous forest and exists largely as a single channel, with the exception of a dry channel and slough that both extend upstream from the right bank. The slough is directly upstream of Site AT8 and is a former side channel of Moore Creek that has been blocked. The slough off Anderson Creek is 525 m long with a mean channel width of 10.8 m \pm 2.6 m and contains Sites MT1 and MT2.

Reach 1 contains limited spawning gravels and is tidally influenced, making it less suitable for Pacific salmon spawning, although chum and pink have been known to spawn in such habitats (Bailey 1964; Groot 1989; Helle 1970). Reach 1 also has reduced cover, which limits its suitability for rearing and overwintering. Large woody debris (LWD) was observed in trace amounts with limited pool depth. Eroding banks are the primary disturbance indicator in Reach 1, which has no barriers to fish movement and is suitable for migrating fish.

Reach 2 extends an additional 575 m through mature coniferous forest upstream into predominantly young deciduous forest with increasing canopy closure. The streambed is dominated by small and large gravels with limited fines. Extensive off-channel habitat connects into wetland areas off the right bank along the east side of the Haul Road and also through a 1,500 mm diameter culvert into a wetland complex west of the Haul Road (9U 520249 5985486). There is also a pronounced side channel off the left bank at the start of the reach.

The dominant form of cover in Reach 2 is medium- to large-sized LWD jams with scour pools. Undercut banks, small woody debris (SWD), and overstream vegetation (OV) also serve as cover, making the reach suitable for holding and rearing. Available side channel habitat is limited due to ephemeral flows. Debris jams are the primary disturbance indicators in Reach 2, which has no observed barriers to fish migration. Overwintering conditions are moderate given the access to deeper scour pools and ponds west of the Haul Road.

Reach 3 is a higher gradient reach (2%) with multiple braids, evidence of aggrading, and extensive off-channel habitat on both sides of the mainstem. Surface flows at Reach 3 extend through young deciduous forest off the alluvial fan created by Anderson Creek, with multiple sources of groundwater input off the right bank. This reach is 200 m long with moderate (21% to 40%) canopy closure and an ill-defined mainstem channel among several perennial and ephemeral braids. Dominant cover is medium-sized (20 to 50 cm diameter) LWD jams. Scour pools serve as additional cover for rearing and holding. Trace amounts of undercut banks and OV also provide suitable rearing habitat.

The head of Reach 3 has an LWD jam approximately 30 m wide across the channel; it is the primary disturbance indicator in this reach. Most surface flow extends south through the braids below the debris jam, which may pose as an obstruction to migrating fish during certain times of the year. Most of the off-channel habitat in this reach is ephemeral with subsurface flow. Ancient woody debris deposits on the fan contain intermittent pooling, but appear to be inaccessible to fish (Section 4.3). Reach 3 is dominated by gravels with a lesser degree of fines and isolated pockets of small cobble. Side channels off the left bank are predominantly composed of fines and organics. The lower portion of Reach 3 has good spawning potential for anadromous salmonids given the groundwater influence, but poor overwintering habitat, especially in off-channel areas.

Reach 4 continues west from the large debris jam under the Haul Road bridge and toward the RTA facility. This reach sits on top of the alluvial fan with a gradient of 1%. It has had previous disturbances, including dredging (Mitchell 2013, pers. comm.) and enhancement, given the presence of a constructed channel south of the mainstem and west of the Haul Road (i.e., Anderson Creek South location area).

The dominant substrate in Reach 4 is gravel with subdominant cobble deposits. There is reduced cover as the channel widens with long side bars, reduced canopy closure (0% to 20%), and an overall lack of complexity. Existing cover is predominantly deep pool and OV with trace amounts of LWD, undercut banks, and boulder habitat (specifically under the Haul Road bridge). Reach 4 is riffle-run habitat with occasional pools suitable for staging or holding and overwintering; three species of adult spawning Pacific salmon (pink, sockeye, and coho) were observed concurrently holding in these pools in September 2012. Large gravel deposits with visible redds suggest high quality spawning habitat in Reach 4, with limited rearing and overwintering habitat.

The most notable observation in Reach 4 is the presence of numerous side channels that drop off the alluvial fan into Beaver Creek. The most significant is Anderson Creek North, a perennial side channel flowing out of the conspicuous debris jam on the left bank, directly upstream of AT4 and west of the Haul Road. Additional channels east of the Haul Road bridge were observed north and northeast from a large dry channel that likely represents the old mainstem of Anderson Creek. Based on field observations, much of the side channel inputs are likely to be groundwater influences that emerge and flow into Beaver Creek as well as Reaches 2 and 3 of Anderson Creek.

Beaver Creek Reach Description

Beaver Creek is the principal tributary to Anderson Creek in the LSA. Reach 1 is tidally influenced above the Anderson Creek confluence; however, it is difficult to discern the point at which Beaver Creek is no longer subject to tidal inputs. There is very little elevation gain overall and Beaver Creek habitat remains quite homogenous. It could be described as a single reach up to the point at which the perennial side

channel of Anderson Creek North enters the mainstem. A beaver dam is directly below this influence and extensive ponding upstream of the dam constitutes a clear reach break.

Reach 1 of Beaver Creek continues for 450 m through mature coniferous forest with open canopy closure (0% to 21%), then transitions into young forest on the right bank and mature, mixed forest on the left bank for an additional 350 m. The remainder of the reach is in deciduous young forest on both banks for a total length of 1,625 m from the main confluence to the beaver dam below the primary side channel influence at Anderson Creek North. This reach has less than 1% gradient and is best characterized as a series of runs with pool habitats and few short riffle sections. Evenly distributed LWD and pools are the dominant forms of cover. Additional secondary cover in Reach 1 includes OV and instream vegetation (IV) to a lesser degree. The IV becomes the dominant cover at the upstream end of the reach. The substrate is dominated by fine sediments with isolated pockets of embedded gravel, thus limiting its suitability as salmonid spawning habitat. The OV and pool habitat provide moderate rearing capacity.

Reach 2 begins at the side channel entrance from Anderson Creek North, above a large beaver pond that extends west through Sites BT3 and BT3A into the pool habitat that receives inputs from Beaver Creek upstream of a debris jam to the north and several smaller, braided perennial channels from Anderson Creek North. These channels have no obstructions and are accessible to fish year round. Reach 2 remains low gradient (<1%) upstream of the debris jam and is a series of indistinct runs and deeper pools that provide rearing and overwintering habitat. Migration is unimpeded except at a point near the upper end of the reach at BT3 where a pipeline RoW, approximately 10 m wide, crosses beneath the stream channel; the channel upstream of the RoW crossing dewateres at low flows.

Predominant cover in Reach 2 is a split between deep pools and LWD, with considerable IV and OV and reduced canopy closure (0% to 20%). Overall this portion of the reach has a high amount of IV that obscures the wetted margins of the channel. The bed material is dominated by fines and organics.

Reach 3 initiates in the Lower Wetland Complex, through which Beaver Creek continues for approximately 300 m upstream to the culverts under the Methanex rail spur. The stream gradient in this location is near 0% with large areas of standing water observed in all directions. Some LWD is evident, but most cover is deep pool and IV, with OV to a lesser extent. No spawning habitat exists due to the lack of suitable conditions. The primary disturbance outside of the infrastructure is a second beaver dam approximately 20 m below the rail spur culverts. A slough continues west past the culverts and through the Lower Wetland Complex connecting ephemeral channels to the culverts along the Haul Road, which drain the ponds on the west side. Dissolved oxygen decreases sharply with much of the wetted habitat observed as hypoxic during the May 2013 sampling.

Overall, Reach 3 of Beaver Creek has poor spawning capacity. The dominant bed material consists of fines and organics; compared to all other reaches, Reach 3 is more of a lentic waterbody. Based on cover characteristics, the reach is suitable for rearing, holding, and overwintering, conditional to depressed DO, which limits the productive capacity of Reach 3 (Section 4.1.3.2).

The final reach examined in the study was Reach 4, a continuous run along a straight, single channel of Upper Beaver Creek. The channel continues for 970 m through a set of culverts under the rail sidings west of Haisla Boulevard. This reach moves along a confined strip of land between the Eurocan mill on the north side and a high-voltage transmission line and Haisla Boulevard, which are to the south. Riparian vegetation on this stretch is mature forest on the right bank and shrubs on the left bank. The Haul Road bends north along an overpass of Haisla Boulevard and confines the direction of flow of Beaver Creek.

The dominant cover in Reach 4 is OV with IV present to a lesser extent. Bed material in Reach 4 is dominated by fines with patches of clean spawning gravel. Reach 4 provides moderate to good spawning, rearing, and overwintering habitat.

Moore Creek Reach Description

Moore Creek is the lowermost stream west of the Kitimat River in the LSA. Although Moore Creek merges with Anderson Creek upstream of the larger estuary channels, it has not been classified as a tributary of Anderson Creek (FISS 2013). The presence of constructed dikes has confined the flow of Moore Creek into Anderson Creek at a single point. As previously mentioned, a smaller dike (9U 520555 5984866) has blocked flow from a side channel into Anderson Creek upstream of sites MT1 and MT2. The second, larger dike (9U 520970 5984870) prevents Moore Creek from entering an estuarine channel and has confined its flow into Anderson Creek to the northeast (9U 521035 5985080).

Reach 1 of Moore Creek is a low gradient (<1%), large channel habitat approximately 850 m in length with apparent tidal influence. The bed material in the lower end of the reach is predominantly fine sediment. Gravel deposits are more dominant in the upstream end of the reach as the gradient increases marginally to about 1%. Riparian vegetation is predominantly grasses and there is minimal to no canopy closure (0% to 20%) with reduced overall cover, most of which is dominated by undercut banks with trace amounts of LWD. The reach is not suitable for spawning and is considered poor to moderate for rearing and overwintering. There are no migration barriers.

Reach 2 has a slightly higher gradient (1%) and is approximately 560 m in length moving upstream and west under a second Haul Road bridge. Riparian vegetation is composed of shrubs with some young forest directly upstream of the bridge. The reach is tidally influenced and contains three sloughs off the left bank, including the upstream portion of the pre-existing side channel to Anderson Creek, blocked off by the dike. A second slough is approximately 50 m upstream and drains from a wetland to the north

along the east side of the Haul Road. Seventy-five metres upstream of the bridge, a third, ill-defined, slough extends from a forested area to the northwest; the water is quite dark, presumably from tannin content. The reach ends in an 80 m long deep run that lies parallel to the Haul Road and pipeline RoWs. This section appears to have been previously constructed to direct flows away from the infrastructure and toward the Haul Road bridge.

Bed material in Reach 2 is predominantly gravels with fines being subdominant. Cover in Reach 2 is dominated by a series of scour pools, undercut banks, and trace amounts of LWD and OV. Boulder cover exists directly under the Haul Road bridge. Reach 2 is less suitable for spawning given the tidal influence and lack of suitable substrate and flow conditions; however, cover allows for suitable rearing, staging/holding, and overwintering. Adult coho salmon have been observed holding in the deep run at the top of the reach during spawning season.

Reach 3 is the uppermost point of investigation on Moore Creek. It is a braided section extending upstream approximately 250 m from the deep run toward a channelized section that flows through the RTA facility footprint. Abundant cover in Reach 3 includes LWD with undercuts. The smaller braids have high canopy closure (>70%) and adult coho salmon have also been observed holding in the deeper scour pools. The reach has poor spawning habitat, but is excellent for rearing.

Kitimat River West

The Kitimat River West location comprises all side channels within the LSA that are primarily connected to the Kitimat River mainstem in Reach 1. Fish habitat was not formally assessed within the Kitimat River, but the observations made during reconnaissance and fish sampling events have provided a general channel description of the two main areas: the Kitimat River side channels and the Kitimat River oxbow channel.

Kitimat River side channels in the LSA are predominately in a mature coniferous and deciduous forest with a thick canopy cover offering abundant shade and cover. Additional cover is provided by OV, LWD, and undercut banks. An established 50 m riparian reserve zone exists along the east margin of the side channels and continues along the oxbow channel. These attributes, along with the low velocities of the side channels, provide good overall rearing habitat for juveniles. Various side channels in this area are ephemeral and could lead to stranding effects at low water levels. Other areas offer perennial habitat for fish. Salmonid spawning habitat throughout the side channels is low quality due to the high content of fine materials, with a subdominant component of gravels; however, the side channel substrate above the oxbow may be well-suited for spawning by eulachon.

The Kitimat River oxbow channel is situated within a mature deciduous forest. It is roughly 1.7 km in length and ranges from 15 to 60 m in width. The outlet of the oxbow channel is perennially connected to

the Kitimat River mainstem, whereas the upstream extent only exhibits connectivity at high water levels. A debris jam at the upstream end of the side channel inhibits influence from the mainstem Kitimat River on the upstream end. Migration of fish throughout the entire oxbow channel likely comes from the downstream end. Beaver activity is widespread throughout Kitimat River West area, which has increased the amount of LWD cover. The LWD has hindered the flow of water and migration of fish due to upstream damming. Evidence of a beaver dam was observed on the side channel directly upstream of the oxbow channel (9U 521149 5986296). Spawning within the oxbow channel is limited by the dominance of fines combined with low stream velocities. Groundwater upwelling was observed, which provides overwintering potential in areas of sufficient depth. Suitable adult fish staging and holding habitat throughout the downstream portion of the oxbow channel can be attributed to sufficient depths and low velocities.

Cecil Creek

Cecil Creek is the control stream located roughly 20 km north of the LSA. It is a tributary of the Kitimat River with the downstream extent of the assessment area situated roughly 11.2 km upstream of the confluence. The area assessed has an irregular meandering pattern that extends unconfined from the upstream side of the Onion Lake forest service road (FSR) bridge (9U 0523063E 6015416N) approximately 400 m downstream (9U 0522982E 6015085N). This area has uniform channel morphology and cover, with seasonal flow.

The assessment area of Cecil Creek is situated in mature mixed forest with a 21% to 40% crown closure. Confinement is a result of steep banks at the Onion Lake FSR bridge. A shallow gradient of <3% persists throughout the assessment area. Bed material is dominated by small and large gravels with a subdominant component of cobble and trace amounts of boulder. An abundance of gravel material is associated with moderate spawning habitat potential for both anadromous and resident fishes. Moderate amounts of cover are dominated by LWD, OV, and undercut banks, all of which provide good juvenile rearing habitat, surface flow permitting. Deep scour pools allow for a moderate level of adult fish staging and holding habitat; however, given the seasonally intermittent flow regime observed in September 2012, the assessment area would be less suitable as overwintering habitat.

4.1.3.2 Freshwater Fish

Closed-site Electrofishing

Parameter estimation for closed sites has displayed abundance N given catchability q for the likelihood estimates of combined species (Table 4.1-13). In terms of the implications of the model, results indicate variability in q (0.409 to 0.767) that does not appear to depend on channel unit type (i.e., riffle, pool, and run habitats), although riffle habitat tends to have higher catchability. That is likely a result of the relatively shallow depths and higher velocities. Also, fish not captured by dip nets accumulate in the lower stop net.

Riffle habitats examined have higher q overall, but run and riffle-run channel units have more variable q , which appears to depend on the season. The lowest estimates for q are found in May and June, during higher flows. This is expected given the higher depths and velocities in run habitat combined with more turbid conditions compared to September. Variability in channel complexity and availability of cover also affects q . The run habitat sampled in Moore Creek was a flat-bottomed channel with limited cover compared to Cecil Creek. These sites have the highest and lowest respective estimates for q among all closed sites in the study, despite both being classified as run habitat.

Total abundance N as a calculated fish density (CPUA) was greatest in September 2012 during the low flow conditions. These closed site estimates corroborate with the CPUE data for open site minnow trapping (Figure 4.1-7 and Figure 4.1-8). Cecil Creek had the highest densities followed by Moore Creek. Run habitats in the LSA yielded higher densities compared to riffle habitats, but this was not observed in the control stream (Figure 4.1-4). This is not surprising since Cecil Creek was first sampled in June 2012 (run habitat); however, the creek was mostly dewatered in September with dead fry observed in residual pools. Fish would have been forced to accumulate in any wetted portions of the stream, irrespective of channel unit type, due to the dewatering effect, which would lead to higher densities in September 2012. In any case, the results show that Cecil Creek's flow regime differs from the streams in the LSA. Therefore, Cecil Creek is not relevant as a control stream going forward.

Beaver Creek was not sampled in closed sites in September 2012, but results from May and June showed fish densities to be lower compared to September. Anderson Creek was sampled in June 2012 in one closed site (AEF-1-2); however, no fish were captured across three passes (Figure 4.1-4). Lower abundance estimates in May and June are likely the result of reduced habitat suitability for fish at higher flows and more turbid conditions. Reduced fish densities in May 2012 and June 2012 compared to September 2012 are also supported by the results from CPUE using other capture methods.

Regression analysis similarly revealed variability in q both among sites and among species within sites. Additionally, the q for individual species differs among sites (Table 4.1-14). Catch data per species were too limited to use the likelihood approach and determine confidence intervals; however, regression analysis can effectively apportion the total catch into species. Sparse catch data for some species will not allow for an assessment of the model fit, so R^2 values of 1 in such cases have been dismissed in Table 4.1-14. Some catch information for certain species fit the model well, particularly coho salmon in Anderson and Beaver creeks.

Considering all seasons and closed sites, coho salmon appears to be the dominant species in the LSA, while cutthroat trout is dominant in the control site Cecil Creek (outside the LSA).

It is theoretically possible to extrapolate total abundance per species in Anderson and Beaver creeks, given the calculated total wetted areas by channel unit. This has not been done for several reasons, the first of which is the parameter uncertainty in the models used. Regression analysis does not give a reliable estimation of confidence intervals given the ill-fitting slopes and few catch data for many species. Any attempt to develop confidence intervals would require assumptions about the distribution of residuals in absence of sufficient catch data. For the purposes of understanding fisheries values in these two streams and among all wetted areas examined in the LSA, relative abundance based on CPUE across seasons is much more informative. It also supplements the results obtained for closed sites.

Open-site Electrofishing

Limited open-site electrofishing activities took place in May and June 2012 (Appendix C, Table C-2, summarizes total catch and effort). Both trips consisted of sampling the side channel habitat between Anderson and Beaver creeks (i.e., Anderson Creek North and Anderson Creek East). Results have shown that these side channels support fish and appear to be more important for fish during intermediate flows compared to higher spring freshet flows, as shown in Figure 4.1-1. No fish were captured in Beaver Creek or Anderson Creek East during the spring sampling sessions. It is surprising that fish were not observed in these side channels, which are expected to be more suitable as refuge habitat compared to the fast-flowing mainstems. The field crew noted conditions in all reaches to be fast flowing and turbid, including the perennial side channel habitats. Such conditions would reduce q , which may have been a factor influencing the perceived drop off in fish densities.

Overall, the results for open-site electrofishing in May and June 2012 indicate that fish densities decline at higher flows and even perennial side channel habitat is not suitable refuge. The inference is that fish likely rely on ephemeral habitats during peak flows; however, these habitats become less important, possibly even detrimental, during seasons of reduced flow. Other factors present in off-channel habitats may limit fish distribution as well.

In May 2013, Triton sampled the Upper Wetland Complex to ascertain fish presence in auxiliary habitats off the mainstem of Beaver Creek. The DO levels recorded were considered lethal to salmonids (0.39 mg/L in Site BEF-3-1 and 1.62 mg/L in Site BEF-3-2). The crew observed several age 1+ coho salmon floating dead in the reeds at the bottom of BEF-3-2. Despite no obvious barrier to access, these fish had somehow become trapped in the hypoxic off-channel habitat. Examination of additional off-channel habitat during March and May 2013 extended in the wetland complexes and more lentic bodies including the Eurocan Slough and Kitimat River oxbow channel. Results indicated that low oxygen habitat exists throughout the LSA (Table 4.1-3) and is likely to limit fish distribution and abundance.

Minnow Trapping

Overall, the mainstems of Anderson, Beaver, Moore, and Cecil creeks had the highest CPUE irrespective of trap type. High variability indicates non-uniform spatial distribution of fish in the LSA. Off-channel habitats also tended to have lower abundances based on mean CPUE compared to mainstems; however, temporal variability cannot be considered due to limited sampling across seasons (much of the off-channel habitat was only sampled in 2013). Overall, it appears that the mainstem channels of all streams in the LSA are of perennial importance to fish, whereas off-channel habitats appear to be seasonally important.

Variability observed in overall CPUE of the combined catch does not adequately account for spatial or seasonal conditions among species. Stage of stream discharge and dispersion of individual species throughout the LSA must also be taken into consideration. Beaver Creek had the highest densities among the three streams. In terms of overall catch composition, the results show that coho salmon is the most significant species in the LSA, especially in the mainstems during low flows associated with the September survey and also during the winter (Figure 4.1-11).

Overall, mainstem channels in the LSA support overwintering juvenile coho salmon. Coho salmon remained quite abundant in the Beaver Creek mainstem in winter compared to Anderson Creek. Moore Creek had coho salmon abundances that were more comparable to Anderson Creek in January. Coho distribution appears to be conditioned on movement between Anderson and Beaver creeks through interconnecting side channel habitat in Anderson Creek North; however, Anderson Creek East cannot be compared because it was not sampled in January or March 2013. Nonetheless, off-channel habitat is seasonally important to coho in the LSA. Juvenile coho occupied off-channel habitats during the winter, particularly the wetland complexes extending off the Beaver Creek mainstem. Beaver Creek's wetland complexes appear to become important in March toward the end of winter based on the Gee trap results for coho salmon, although only a limited amount of sampling occurred in other seasons.

All trapping data west of the Haul Road indicate the pond habitats in the Lower Wetland Complex did not contain fish. Accessibility to these ponds is especially limited during low flows and the ponds likely do not support fish in all seasons because of the depressed DO levels observed (recall DO levels <1 mg/L in May 2013). Coho were captured on the northeast side of the Haul Road and as far west as the culvert under the RTA rail spur in January (Site CMP-2; 9U 519388 5986887). This confirms fish presence throughout the Lower Wetland Complex on the east side of the Haul Road, which can only be accessed by fish from Beaver Creek.

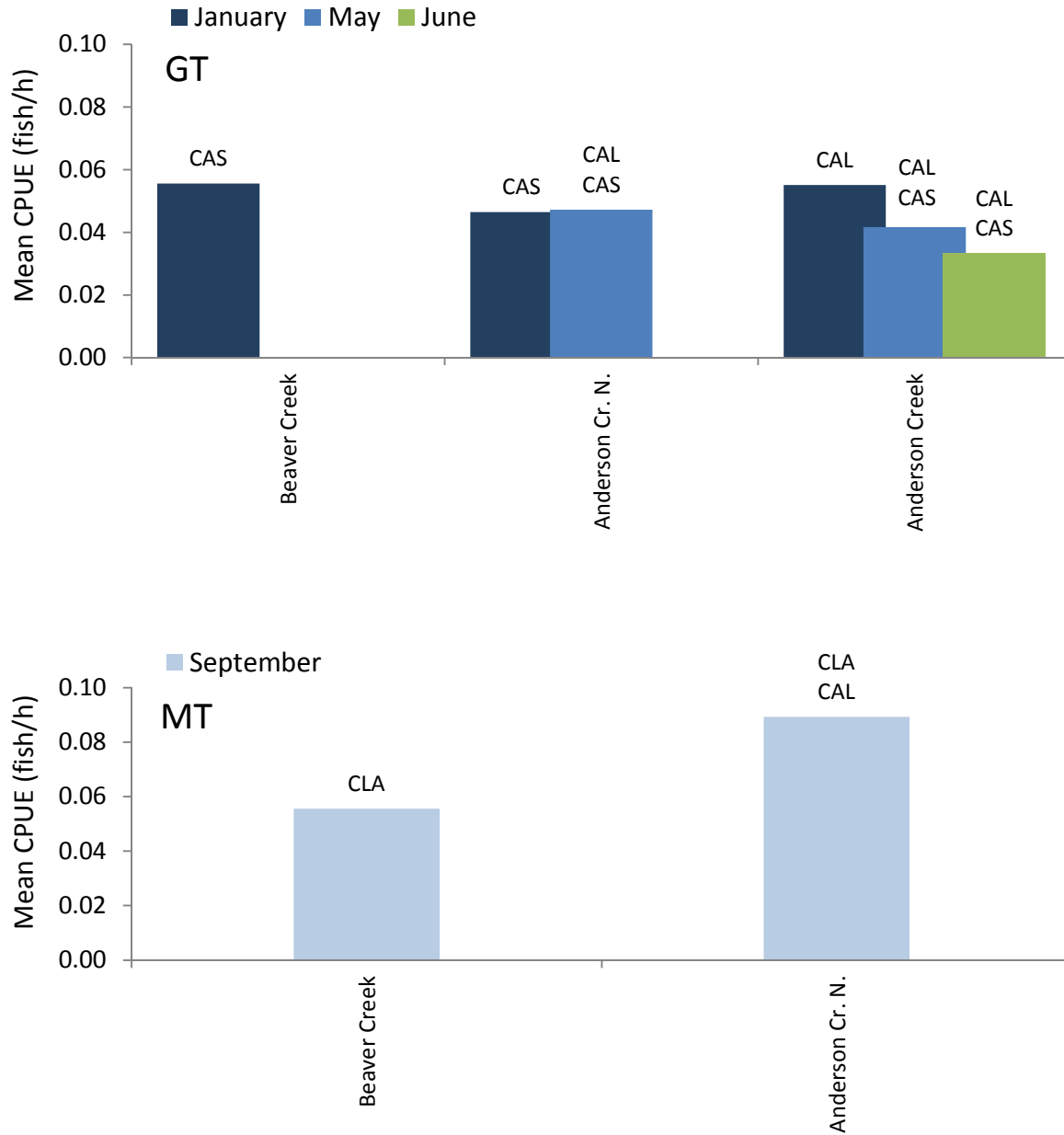
Minnow trapping CPUE showed that wetland complexes became more important to coho salmon toward the end of winter. This is likely to be due to movement out of the mainstem in Beaver Creek as flows increase (Figure 4.1-11). Additional wetland habitats of Anderson Creek South also had elevated coho

salmon densities in March compared to January. This habitat is perennially accessible through the culvert under the Haul Road from Reach 2 of Anderson Creek. Moore Creek was not sampled in March, so such a comparison cannot be made for this stream.

Off-channel habitats, including the Lower Wetland Complex, Anderson Creek North, and the Dike Area, had higher coho salmon densities than the mainstem channels of Anderson and Beaver creeks in May of both years. Moore Creek proper (upstream of the dike on the side channel) was not sampled during May and thus cannot be compared. It appears that coho salmon continue to move into both perennial and ephemeral off-channel habitats as flows increase, although distribution is dependent on DO availability. Triton observed coho salmon in the perennial side channels of Anderson Creek East that drain into lower Beaver Creek. Coho salmon juveniles were also observed during the May 2013 side channel inventory, especially off the left bank of Anderson Creek. These ephemeral side channels were completely dry in September 2012. Other off-channel habitats included the Upper and Lower Wetland Complexes, wetland areas on either side of the dike, and the ponds west of the Haul Road. These sites contained few to no fish and had the lowest DO values observed in May 2013.

June 2012 sampling took place during the highest stage of stream discharge in the study. Trapping efforts showed that mainstem Beaver Creek is more important for coho salmon at high flow, whereas Anderson Creek had reduced densities (Table 4.1-14); this is the opposite of what was observed using the open-site electrofishing sampling method. There are multiple reasons to explain this, but they all ultimately result in differences in q between the two methods. Minnow trapping in June would have higher q than electrofishing for several reasons, mainly because it is a passive capture method that is not influenced by turbidity. Electrofishing is an active, visual capture method and was greatly impaired by the turbid conditions in June 2012. Higher q with minnow trapping can also be attributed to the fact that fish do not visually locate bait in traps; rather, bait is detected chemically. Once fish are trapped, turbidity further impedes the ability to escape traps using visual means. Consequently, minnow trapping was more credible as a capture method for determining CPUE compared to open-site electrofishing. It also supported the results showing mainstem Beaver Creek to be an important location for coho salmon during high flows and therefore important during all seasons.

Other species detected through minnow trapping include additional salmonids (Figure 4.1-12), threespine stickleback (Figure 4.1-13), sculpins (Figure 4.1-14), several coastrange sculpin in Beaver Creek, and a single starry flounder in Moore Creek. Chum salmon was only observed during dip netting in the Kitimat River oxbow in March 2013, which confirmed that juvenile chum occupy this habitat, at least during spring out-migration. Conditions do not appear to be favourable for spawning salmonids based on observations of the habitat (see Section 4.1.2.1). A single chum salmon carcass was observed in Anderson Creek during the September survey while pink salmon was the predominant spawning species.



NOTES: * GT = Gee traps; MT = mesh traps
 CAS – prickly sculpin, CAL – coastrange sculpin, CLA – Pacific staghorn sculpin

Figure 4.1-14: Seasonal Catch Distribution for Sculpins Expressed as Mean CPUE*

All spawning adults in the study were observed in Anderson Creek. Chinook salmon were only observed in Beaver Creek during May 2012, although it is unlikely that these few juvenile specimens captured would have emerged from redds in Beaver Creek, given limited and unfavourable spawning habitat. Chinook salmon has previously been recorded in Anderson Creek (Map A-4), so it is more plausible that the Beaver Creek observations are migrants from Anderson Creek through the perennial side channels local to the Anderson system, or from Kitimat River through the estuarine channel. These channels consistently appear to be important determinants of fish distribution in Beaver Creek.

Non-anadromous salmonid species included Dolly Varden char and rainbow trout. Cutthroat trout was only observed in the control stream as the dominant species, based on all capture methods. Triton observed Dolly Varden in Cecil, Anderson, and Beaver creeks in June and September. Rainbow trout were also captured in Anderson Creek ($n = 11$), Anderson Creek North ($n = 2$), and Moore Creek ($n = 1$), but not in Cecil or Beaver creeks. Absence of rainbow trout in Cecil Creek is likely due to the cutthroat trout dominance in this stream. In Beaver Creek, rainbow trout have free and continual access from Anderson Creek through the perennial side channels where they were observed; however, Beaver Creek habitat may not be as suitable for rainbow trout. Anderson Creek rainbow trout are likely to be a non-anadromous stream-resident ecotype that prefer more lotic conditions with more favourable spawning substrate. Rainbow trout would still be able to exploit habitats in Beaver Creek for rearing and overwintering. Although it has not been detected in Beaver Creek in this study, Appendix A (Figure A-5) indicates a presence of rainbow trout in Upper Beaver Creek, along with cutthroat trout. As stated, Triton did not observe cutthroat trout anywhere in the LSA.

Threespine stickleback is the second most abundant species in the LSA after coho salmon. Figure 4.1-13 shows threespine stickleback to be most abundant in Beaver Creek in September (11.20 fish/h). Most fish were captured using Gee traps in slow-moving run and pool habitats in the upper end of Reach 2, where IV is the more dominant form of cover. Anderson Creek also had high threespine stickleback densities; however, these results come mostly from dense concentrations observed in a more tidally-influenced slough directly upstream of AT8 (i.e., the former interconnecting side channel of Moore Creek). As for freshwater habitats, it appears that threespine stickleback prefers ponds and pools in the wetland complexes and Anderson Creek South as well as other sloughs including the Dike Area, Eurocan Slough, and the oxbow channel in Kitimat River West. The highest concentration of threespine stickleback in off-channel habitat was in the southern half of the Dike Area in March 2013. This area is also quite tidally influenced so this result was to be expected, given that threespine stickleback is relatively abundant in estuarine habitats in the LSA. Threespine stickleback is known to occupy both freshwater and marine habitats.

A general pattern for Gee trapping effort in Figure 4.1-13 shows overall reduced threespine stickleback density in January with increases in March and June up to a maximum density in September. Reasons for this are not entirely clear. Threespine stickleback density may be influenced by seasonal factors that affect q or possible effects from movement throughout the LSA and/or between freshwater and estuarine habitats, given the observed abundances of threespine stickleback in estuarine sites.

The remaining species observed in the LSA include sculpins, lamprey, and starry flounder. Sculpins are quite evenly distributed between location areas and across seasons. These species tend to be quite localized and non-migratory, which makes them an ideal sentinel species for impact assessment (Paradis 2013, pers. comm.). All three sculpin species were also observed in Anderson Creek North indicating that perennial side channels are important habitat for sculpins. Pacific staghorn sculpin was found in Beaver Creek near the upper end of Reach 2 with threespine stickleback; this species is found in both freshwater and marine environments. Triton did not observe Pacific staghorn sculpin in Anderson Creek's mainstem channel and no sculpins were trapped in Moore Creek, but coastrange sculpin was the second most abundant species to be electrofished in closed sites in Moore Creek.

Lamprey observations were restricted to specific locations in Anderson and Beaver creeks. One specimen was trapped near to where four fish had previously been captured in a closed site (BEF-1-2; 9U 520196 5986482). The aggregation of lampreys appears quite isolated and was the only location where the species was trapped. Triton did not identify the lamprey to species, but it is likely to be either Pacific lamprey (PL) *Lampetra tridentata* or river lamprey (RL) *Lampetra ayresi*.

Anderson Creek

Results indicated that Anderson Creek supports four species of Pacific salmon, with coho as the most abundant species based on the catch data; however, pink salmon had the highest spawner densities during the September visit. The coho spawning migration was still in its early stage and chum spawning had already concluded; a single adult chum carcass was observed at the downstream end of Reach 4. Triton observed pink, coho, and sockeye salmon holding in the large pools in the lower end of Reach 4. Additional adult coho were observed holding in LWD and OV cover in Reach 3. A series of weirs upstream of Reach 4 in the channelized section through the RTA facility are likely important for cover and for holding during spawning events. About 1,200 m of stream flows between the downstream portion of Reach 4 and the Haisla Boulevard bridge, where a >2 m falls exists (9U 519095 5985755). Any adult salmon that surmount this obstruction only have an extra 420 m of stream available for spawning up to Anderson Creek falls (9U 518711 5985773), which is the upstream barrier to migration. This limits the capacity of Anderson Creek to support Pacific salmon spawning upstream of the LSA.

Juvenile salmon observed in the mainstem of Anderson Creek are predominantly coho, whereas juvenile pink and chum salmon migrate to the estuary upon emergence (McPhail 2007) and have not been observed during any of the sampling events. The one exception was three chum fry caught among a dense concentration of threespine stickleback in the Moore Creek slough of Reach 1 during May 2012. This is not surprising given the tidal influence and estuarine-like conditions of the slough. It may also be that the chum salmon observed in the slough became trapped by its brackish conditions compared to the flowing freshwater conditions in mainstem Anderson Creek.

Anderson Creek supports rainbow trout and Dolly Varden char up to older age classes. Results from winter sampling show that juvenile coho salmon overwinter in Anderson Creek scour pools and that LWD in Reaches 2 and 3 are good cover for a mix of species, including coho salmon, rainbow trout, and Dolly Varden.

Off-channel habitats in Anderson Creek support fish, especially the perennial side channels of Anderson Creek North and Anderson Creek East, which provide direct access to Beaver Creek. Coho salmon was the dominant species captured in the Anderson Creek North channel during all sampling events, including January 2013. Stickleback, rainbow trout, Dolly Varden, and sculpins also occupy these side channel habitats, but to a lesser degree. Other side channel habitats are more ephemeral or groundwater fed, but they support fish when flooded at intermediate to high stages of stream discharge. The off-channel habitats on the left bank of Reaches 2 and 3 of Anderson Creek were observed to be completely dry in September, but were flowing in May 2013 and supported juvenile coho salmon.

Fish in Anderson Creek South have no upstream access to Anderson Creek due to the placement of a log crib abutment (9U 519837 5985721) along the right bank at the upstream end of the constructed side channel. The culvert under the Haul Road on the downstream end (9U 520243 5985483) provides access to the wetland and beaver ponds for fish. Stickleback were abundant in these ponds and coho salmon was the only salmonid species observed in January and March, which means that Anderson Creek South might retain important coho overwintering habitat. As a comparison, wetland areas on the north side of Anderson Creek (i.e., Lower Wetland Complex west of the Haul Road) do not have obvious connectivity to Anderson Creek or the Anderson Creek North channel draining into Beaver Creek. Consequently, no fish have been observed in these ponds. Ponds next to the Haul Road have culverts that lead to Beaver Creek, but no fish were captured here either. The ponds had very low DO levels in May 2013 (approximately 1 mg/L), which cannot sustain salmonids. Dissolved oxygen appears to limit fish distribution in the wetland complexes of the LSA. Wherever surface connectivity exists, these ponds could temporarily support fish as a refuge during high flows, but limiting abiotic factors like DO would restrict use for prolonged periods and could also lead to lethal effects from entrapment.

Beaver Creek

No spawning adult salmon have been observed in Beaver Creek. Juvenile coho salmon and threespine stickleback were the most abundant species in Beaver Creek. Observations of other species include two juvenile chum salmon observed in May 2012 and Dolly Varden observed in June and September. Stickleback and coho salmon were also present in side channel habitats possessing good flow characteristics, although much of the off-channel habitat is likely unsuitable during low stages of stream discharge due to dewatering and subsequent stranding effects. The residual pools are also likely to be susceptible to depressed oxygen levels that could be lethal to isolated fish.

A closer examination of the wetland habitats extending off Beaver Creek and its main side channels provides additional support for the hypothesis that DO is a principal determinant of fish distribution in the LSA. Deliberate attempts to sample fish in the wetlands on the northwest end of the Dike Area revealed that fish are not present in wetland habitat on either side of the dike. On the west side of the dike and extending to the principal Beaver Creek side channel, no fish were captured in the wetland habitat; however, traps simultaneously set approximately 5 m from the edge of the wetland in flowing parts of the stream yielded high numbers of juvenile coho salmon and some threespine stickleback. In this case, DO was again a determinant because only those traps containing fish had DO levels that could support salmonids.

Only coho salmon and threespine stickleback have been observed upstream of Reach 2 in the Lower Wetland Complex of Beaver Creek. Coho salmon was the dominant species followed by threespine stickleback. Lampreys have only been observed in June 2012, as far upstream as the stream habitat directly below the collapsed bridge near BT2, where a high concentration of threespine stickleback was also captured in September 2012. Systematic trapping efforts in May 2013 along the narrow channel that drains culverts along the west section of the Haul Road revealed a gradual drop in densities of coho salmon and threespine stickleback moving west toward the RTA rail spur away from Beaver Creek. Fish became absent in sites where the DO level dropped below 3 mg/L; however, January 2013 trapping efforts at the westernmost culvert on the Haul Road and to the west of the RTA rail spur (CMP-2; 9U 519396 5986876) revealed low densities of coho salmon (i.e., two fish captured) and threespine stickleback (i.e., one fish captured) in 10 Gee traps set overnight. A single northwestern salamander (*Ambystoma gracile*) larva was also captured, which might be another indicator of fish distribution limits. Previous studies have documented larval amphibian presence to be inversely correlated with fish presence, piscivorous fish (Petranka 1983; Hecnar and M'Closkey 1997), as well as planktivores and benthivores (Herwig et al. 2013). Deeper pools in the wetland complex are valuable as refuge for juvenile coho salmon, but overall distribution appears to be limited by the hypoxic nature of the more shallow peripheral wetted areas at certain times of the year, even though access is otherwise unimpeded.

The Upper Wetland Complex showed similar fish distribution limitations. Stickleback and coho salmon were once again the only species observed and the densities were highest in the habitats closest to the mainstem of Beaver Creek. Triton captured few threespine stickleback and coho salmon while electrofishing the off-channel habitat near the Methanex access road in May 2013, approximately 250 m north of mainstem Beaver Creek in the Upper Wetland Complex. Catch included several brightly coloured threespine sticklebacks (i.e., spawning coloration) and two age 1+ coho salmon. Oxygen levels were very low (<0.5 mg/L) and the crew observed four recently dead juvenile age 1+ coho floating on the surface in the reeds of the off-channel habitat. One inference is that these fish moved into such marginal habitats during wet periods with high flows and became trapped once flows subsided.

The ponds on the north end of the Upper Wetland Complex also contained low densities of coho salmon and threespine stickleback, but northwestern salamanders and rough-skinned newts (*Taricha granulosa*) were incidentally captured in this area over the winter (January and March 2013). Such amphibian presence is another indicator of the limits of fish distribution in Beaver Creek. The ponds are drained by the smaller 600-mm culvert to the west under Haisla Boulevard (9U 519638 5987360), so it is likely that fish can only access the ponds during seasons of high discharge. These ponds do not have any apparent connectivity with the Eurocan Slough, which drains into the Kitimat River from the east side of the Methanex access road. The slough supports threespine stickleback with low densities of coho salmon.

Upper Beaver Creek supports coho salmon year round. During winter, Upper Beaver Creek had slightly warmer temperature than Anderson Creek; its surface was open and flowing while Anderson Creek was completely frozen over. Coho are relatively abundant here, suggesting active spawning in Upper Beaver Creek. Spawners can access this habitat either directly from Beaver Creek or through the side channels that connect to Anderson Creek.

Moore Creek

Moore Creek also supports a spawning run of coho salmon, although no adult spawners were directly observed in the study. Catch data indicated high densities of juvenile coho as well as lower densities of threespine stickleback and few sculpins. The juveniles occupy Moore Creek year round as numerous fish were captured in high densities in minnow traps in January 2013. Moore Creek was also the only stream in the freshwater survey observed to support starry flounder. A single starry flounder was caught while electrofishing and is suspected to have been recaptured later in a minnow trap set nearby, based on its measured length and mass.

Kitimat River West

The primary basis for sampling the Kitimat River was to ascertain whether any habitat in the LSA supports eulachon spawning activity. Based on historical information in Section 3, the Kitimat River West study area location is the most likely eulachon habitat in the LSA. Eulachon was not observed in this study. Triton reported active spawning in the nearby Kemano system (Frederiksen 2013, pers. comm.), which coincided with the March 2013 sampling session. All trapping efforts throughout the oxbow and side channels revealed only coho and chum salmon and threespine stickleback presence, but in relatively low densities. The side channel extending north to the Kitimat River mainstem (9U 521052 5986735) is ephemeral and was not observed to flow during the winter or in March during the eulachon spawning season. Conditions in the oxbows are not suitable for eulachon spawning either, meaning that only a short section of this side channel (approximately 250 m) could potentially serve as spawning habitat.

The oxbow channel in Kitimat River West is tidally influenced and the catch data from the side channels draining in from the north showed a reduced presence of coho salmon. Dip netting and observations of dead, stranded chum salmon along the oxbow shoreline also revealed potential chum salmon spawning activity in the area, or ephemeral use by out-migrating juveniles during the March 2013 survey.

Side channels that drain out of the oxbows to the south are blocked from the estuary by the long dike. Trapping efforts in the large pool at the east edge of the dike (DMT-1; 9U 520957 5985441) yielded strong threespine stickleback presence, but very low numbers of juvenile coho salmon. Coho can only have access to the pond from the upstream side channel, which was observed to drain out of the oxbows during the November 2012 reconnaissance trip. A single coho fry was observed frozen in the ice of this side channel during the January 2013 trip.

Cecil Creek

Cecil Creek served as the control stream for the freshwater fish and fish habitat component of the study. Stream-level differences have been observed between Cecil Creek and streams in the LSA. The most notable feature is the presence of cutthroat trout in high numbers in Cecil Creek. Cutthroat trout has not been detected in the LSA, although background information indicates that cutthroat trout are found in Kitimat River, Moore Creek, and Beaver Creek (Appendix A, Figure A-5). Rainbow trout have been detected in the streams in the LSA, but were absent from Cecil Creek based on observations during the study period. Juvenile cutthroat and rainbow trout have been known to segregate into geographically distinct habitats with cutthroat trout occupying smaller, higher elevation tributaries (Hartmen and Gill 1968) most comparable to Cecil Creek.

4.2 Estuarine Fish and Fish Habitat

Field methods and site locations for the estuary study follow those developed by Slaney et al. (1982). The sampling program considers historical information of fish use in the Kitimat River Estuary, which is subject to a high degree of variation in abiotic factors over the seasons and throughout the study area. Winter salinity levels approach 30‰, while spring runoff can lead to a surface freshwater lens that exceeds a depth of 10 m in May and June (Slaney et al. 1982). A seasonal component guided the data collection process over the course of the study period in consideration of Pacific salmon species, eulachon, and other valuable marine fisheries in Douglas Channel.

4.2.1 Methods

4.2.1.1 Timing

The Kitimat River Estuary was sampled at regular intervals over the course of the year, from April 2012 to June 2013. During spring freshet and fry emergence for Pacific salmon species (April through June 2012 and March through June 2013), sampling took place every two weeks. No sampling occurred during July and August. During fall and winter (September 2012 through February 2013), monthly sampling resumed. Field crews visited the sites at favourable tides during the middle of each month. Given the latitude, the study area had short periods of daylight over winter. This required crews to sample on days that would capture the entire amplitude of tides receding from peak to trough during daylight hours. Table 4.2-1 summarizes sampling dates in the study period.

Table 4.2-1: Kitimat River Estuary Sampling Dates – 2012 and 2013

Date	Tide Range	Sample Time
2012		
April 20	1.6 m – 5.0 m	13:50 h – 19:46 h
May 2	1.6 m – 4.6 m	10:52 h – 16:59 h
May 17 – 18	1.9 m – 4.6 m	12:11 h – 18:39 h
May 29 – 30	1.7 m – 4.2 m	07:52 h – 15:13 h
June 11 – 12	1.6 m – 4.4 m	07:13 h – 14:30 h
September 13 – 15	1.1 m – 5.5 m	12:24 h – 19:41 h
October 17 – 19	1.9 m – 4.6 m	14:50 h – 23:19 h
November 10 – 12	0.3 m – 6.3 m	09:53 h – 17:59 h
December 10 – 12	0.2 m – 6.3 m	10:01 h – 18:33 h
2013		
January 9 – 11	0.2 m – 6.4 m	10:34 h – 19:08 h
February 20 – 22	1.3 m – 5.0 m	09:03 h – 17:37 h
March 6 – 8	1.0 m – 5.4 m	07:51 h – 17:00 h

Date	Tide Range	Sample Time
March 20 – 22	1.7 m – 4.5 m	07:57 h – 17:10 h
April 3 – 5	1.4 m – 5.0 m	07:15 h – 16:37 h
April 21 – 23	1.4 m – 4.9 m	10:43 h – 18:27 h
May 4 – 6	1.6 m – 4.8 m	09:42 h – 17:50 h
May 19 – 21	1.8 m – 4.3 m	08:48 h – 16:56 h
June 3 – 5	1.9 m – 4.5 m	10:26 h – 18:03 h

4.2.1.2 Study Sites

Study sites included in the estuarine fish and fish habitat assessment were tidal channels in the LSA and near Project infrastructure. As mentioned, the estuary has been heavily modified by previous developments. Modifications include road, pipeline, and transmission line RoWs; dikes; wharves; foreshore dredging; and other erosion barriers that line the industrial sites and landfills at the edge of the estuary. The extent of tidal channels in the LSA includes a number of these modifications, but becomes more naturalized moving eastward toward the Kitimat River and beyond into Minette Bay.

Triton identified a total of three sites in the LSA (Table 4.2-2) composed of narrow channels that cut through fine sediment layers and are regularly inundated by tides. Site EA-1 is in a portion of the estuary directly west of the RTA Wharf “B”. It is a narrow 3 m channel that floods the upper edge of the bay during high tides. Large woody debris and driftwood are densely scattered along the perimeter of the channel.

Two remaining sites in the LSA are directly adjacent to a large estuarine channel approximately 50 m wide extending 1,500 m from the edge of the estuary directly east of the RTA Wharf “B”. The channel moves in toward Moore and Anderson creeks, but is truncated by a dike at the end of this channel where a high-voltage transmission tower sits (9U 521057 5984883). The channel borders a grassy meadow extending out from the mature forest and wetlands. Site EA-2 is a short channel with coarser substrates and is located directly east of the RTA Wharf “B” access road. It drains off a saltmarsh bounded by forest and wetland to the north and the access road to the west. Site EA-3 is a longer meandering channel located further east toward the river. The channel cuts through fine sediments up to the edge of the dike.

In addition to these three sites in the LSA, Triton established a reference site (EC-1) located in a narrow tidal channel of similar characteristics in Minette Bay on the east side of the Kitimat River (Appendix A, Figure A-3). For comparative purposes, the reference site was sampled concurrently with all estuarine study sites in the LSA.

Table 4.2-2: Estuary Site Information

Site	UTM	Channel Area (m ²)
EA-1	9U 0520554 5983999	1,190
EA-2	9U 0520805 5984134	80
EA-3	9U 0521177 5984454	1,180
EC-1	9U 0524235 5986481	244

4.2.1.3 Fish Sampling

Triton used standard 15 m x 3 m x 6 mm mesh beach seines as stop nets to capture fish in the channels during flooding. Marker points identified the wetted area upstream of each site using 2 by 4 inch planks driven into the substrate as stakes. These wooden stakes, positioned on either side of the channel, were painted bright orange at the upper tips for easy identification and served as anchor points for setting the seine at high tides. Once the site markers had been established, the field crews visited each site approximately 30 minutes after high tide to set the seine across the channel, securing the lead line into the substrate to seal off the channel and propping the floating end up above the surface of the water with lengths of rebar pounded into the substrate with a sledge hammer.

After positioning the net at each site, Triton collected in situ water quality parameters using a handheld YSI Professional Plus[®] standard water quality meter (Table 4.2-3). Approximately 1 hour before low tide, all fish entrapped on the landward side of the net were salvaged in buckets and transported in oxygenated water to a nearby sampling station for processing. If the channel was not sufficiently dewatered at this point, the crew used a pole seine from approximately 20 m upstream of the net to push any fish remaining in the channel into the stop net. Triton identified the species and recorded total length for non-salmonids and fork length for salmonids (± 1 mm) and wet body mass (± 0.1 g), then released all surviving fish back to the oxygenated waters of the larger channel.

Table 4.2-3: Water Quality Parameters Collected for Estuary Sampling Protocol

Parameter	Units
Temperature	°C
DO	% and mg/L
Salinity	‰
pH	pH units
Conductivity	μ S/cm
Specific Conductance	μ S/cm
ORP	mV
Pressure	mm Hg

4.2.1.4 Data Analysis

Morphometric Analysis

Catch data from the estuary sites have been included in the baseline assessment to examine the growth parameters for each species. Triton completed a length-weight analysis for each species in the total catch at all sites, which is useful in assessing growth rates among species found in estuarine habitats. The analysis can also be used to predict stock biomass from length data when weights are unknown (Hilborn and Walters 1992). It is a simple power function denoted as:

$$W = aL^b$$

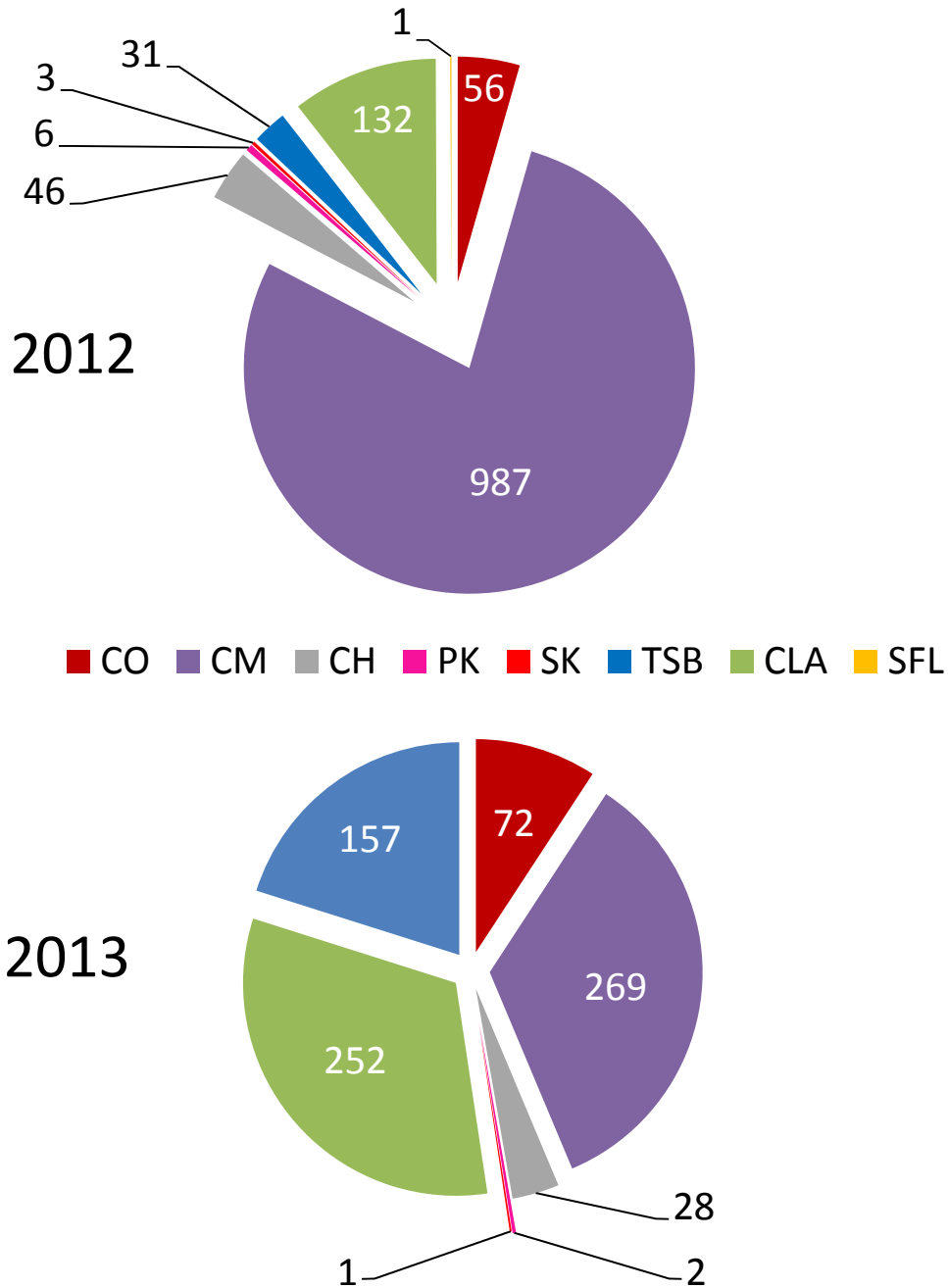
where the weight of a fish W varies as a function of its length L according to the parameters a and b . Triton compared the length-weight relationship among species captured in the estuary sites using the log transformation of data for the power function, which transforms the model to a linear function (Schneider et al. 2000):

$$\log(W) = \log(a) + b \log(L)$$

where the parameter a represents the intercept and b is the slope of the functional relationship. Triton used a regression analysis to statistically evaluate the parameter estimates for each species.

Standardized CPUA

Relative abundance of species in the estuary has been presented for each year in Figure 4.2-1. Variability in site characteristics included wetted area and number of sets per month (i.e., spring events had more than one sampling period). Additionally, Triton did not sample at every estuary site in the full series of monthly sampling sessions, as sites EC-1 and EC-2 were included at later dates. Total catch alone is thus not an informative means of assessing the relative abundance and species composition among sites. Catch per unit area (CPUA) was used to analyze the catch in terms of per unit densities, in this case fish per square metre, given that stop nets have been placed in permanent locations in each tidal channel. The area upstream of the nets is not expected to change significantly.



NOTE: CH – chinook, CM – chum, CO – coho, PK – pink, SK – sockeye, TSB – threespine stickleback, CLA – Pacific staghorn sculpin, SFL – starry flounder

Figure 4.2-1: Species Composition for Total Catch in the Kitimat River Estuary – 2012 and 2013

To determine monthly CPUA at each site, total monthly catch is the sum of the catch for each set within a given month. Due to variation in the number of sets per month, total catch had to be standardized as a catch per set by dividing the total monthly catch by the number of sets in the month, which is essentially a mean catch per month. The standardized CPUA for each site given the month is this mean catch divided by the area (m^2) of the site.

A standardized monthly CPUA for each site has been used to determine relative abundance for the combined total catch and according to species. Sets that did not retain certain species must still be counted (i.e., $C_m = 0$) to reconcile any variation in the number of sets in each month. If a particular month only had one set and no fish of a particular species was observed in that set, the resulting CPUA must remain comparable to other months with greater than one set, which may only have retained certain species in a portion of the total number of sets.

4.2.2 Results

Use of the estuarine habitats by fish species is dependent on numerous abiotic factors, including key water quality parameters (Table 4.2-4). Refer to Appendix D, Table D-1, for a more comprehensive table of monthly water quality parameters across sample sites.

Table 4.2-4: Water Quality Summary by Site

Site	Temp (°C)		pH		DO (mg/L)		Salinity (‰)		ORP (mV)	
	mean	σ	mean	σ	mean	σ	mean	σ	mean	σ
EA-1	8.6	4.24	7.4	0.51	8.79	2.14	16.64	9.51	45.93	126.55
EA-2	7.7	5.15	7.4	0.53	9.79	1.97	11.83	10.70	84.25	126.06
EA-3	6.8	4.22	7.3	0.42	9.37	2.51	8.71	9.38	124.93	89.56
EC-1	7.2	3.52	7.6	0.92	9.21	1.44	13.61	10.64	65.68	77.84

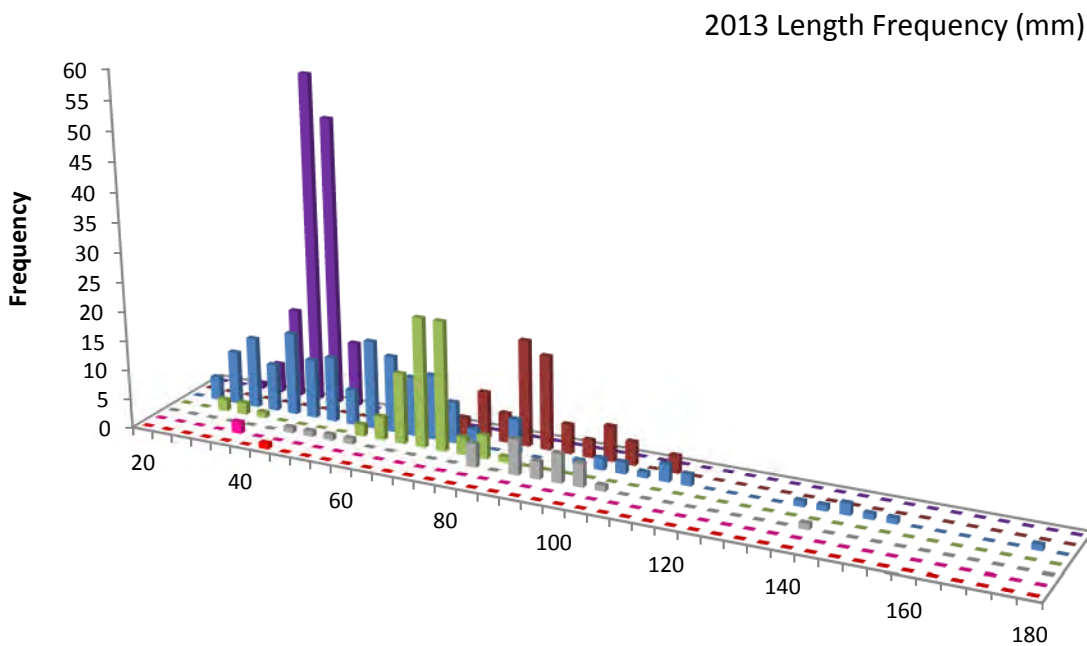
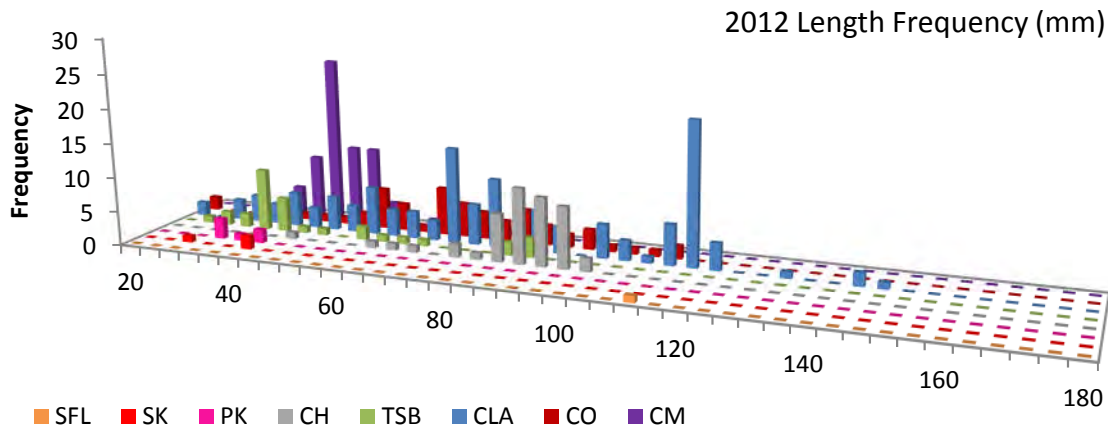
NOTE:

σ – standard deviation

As a general overview of the catch data from 2012 and 2013, Figure 4.2-1 displays the species catch composition for all sites included in the study. Catch data for all sites included morphometric indicators of length (mm) and weight (g) per fish (Table 4.2-5), with few exceptions on certain visits (e.g., high winds prevented reliable weights) and large catches, which increase the risk of mortality when measuring both variables. In these cases, Triton measured a subsample of the total catch per species.

Triton did not collect any age structures from the catch, but inferred multiple age classes were present. The frequency distribution of length measurements across species in the 2012 and 2013 catch data is

displayed in Figure 4.2-2 for all species observed. The result of the length-weight regression analysis for all species is presented in Table 4.2-6. Figure 4.2-3 displays the length-weight relationship among species.



NOTE: CH – chinook, CM – chum, CO – coho, PK – pink, SK – sockeye, TSB – threespine stickleback, CLA – Pacific staghorn sculpin, SFL – starry flounder

Figure 4.2-2: Length Frequency Distributions for the Kitimat River Estuary – 2012 and 2013

Table 4.2-5: Morphometric Summary of Estuary Catch Data

Species	2012		2013		Total	
	mean	σ	mean	σ	mean	σ
Length (mm)						
CH	86	11	86	19	86	14
CM	44	6	40	4	41	5
CO	72	18	86	10	80	15
PK	34	4	35	1	34	3
SK	35	8	44	–	37	8
TSB	47	20	66	11	60	16
CLA	79	30	58	28	67	31
SFL	111	–	ND	ND	111	–
Weight (g)						
CH	6.74	1.51	6.17	5.46	6.61	2.79
CM	0.75	0.34	0.43	0.17	0.49	0.25
CO	4.23	3.46	7.42	2.70	6.24	3.36
PK	0.32	0.11	0.24	–	0.30	0.10
SK	ND	–	0.48	–	0.48	–
TSB	1.83	2.58	4.23	2	3.19	2.61
CLA	9.02	11.74	5.70	11	7.24	11.64
SFL	17.70	–	ND	–	17.70	–

NOTES:

σ – standard deviation

ND – not detected

– insufficient data

CH – chinook, CM – chum, CO – coho, PK – pink, SK – sockeye, TSB – threespine stickleback, CLA – Pacific staghorn sculpin,

SFL – starry flounder

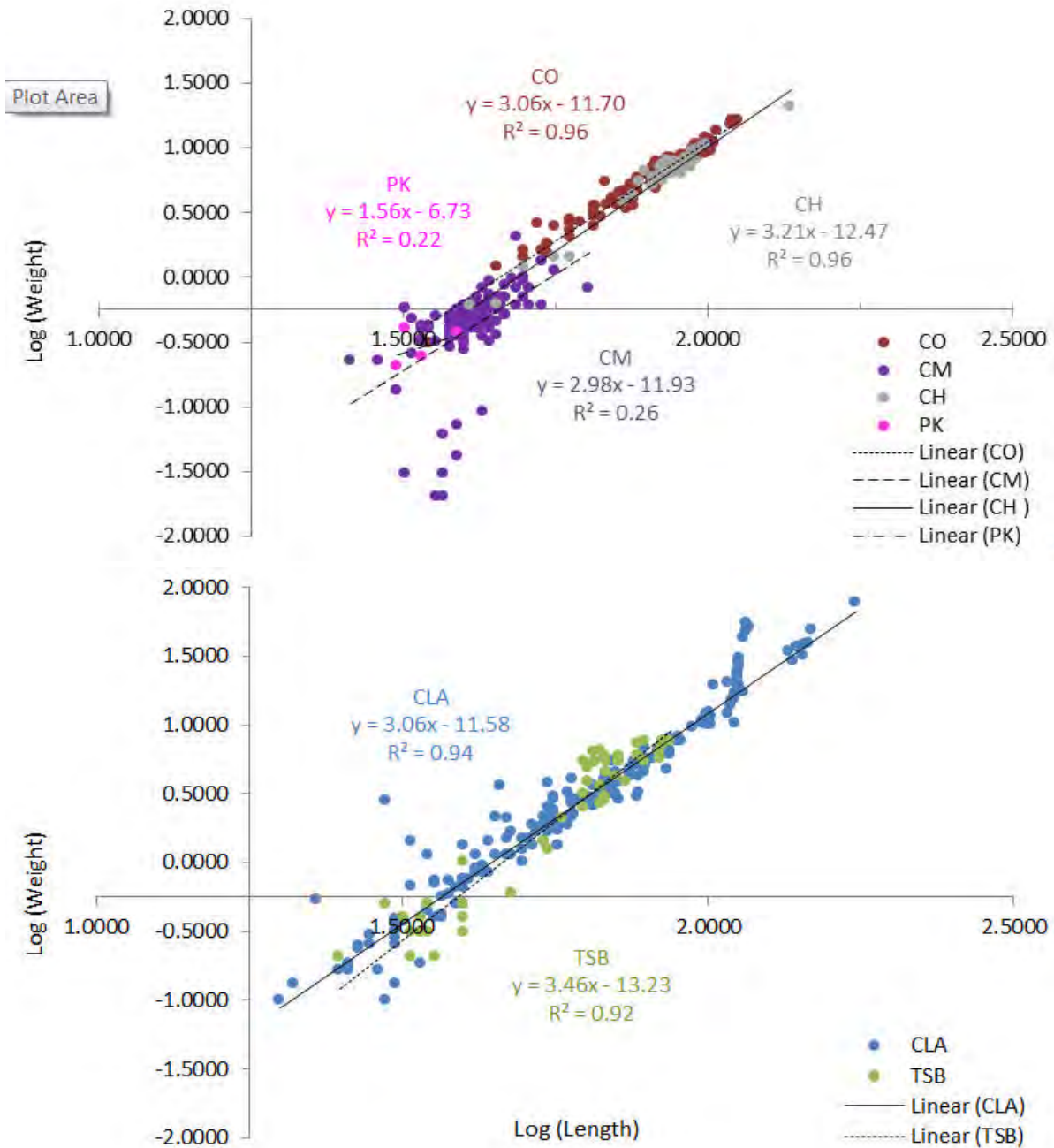
Table 4.2-6: Results of Regression Analyses of Log-transformed Length-Weight Relationships for each Species

Species	Slope (b)	Intercept (a)	n	df	F	Significance F	R ²
CM	2.98	-11.93	130	1	48.64	0.0000	0.28
CH	3.21	-12.47	57	1	1,363.62	0.0000	0.96
CO	3.06	-11.7	103	1	2,274.35	0.0000	0.96
PK	1.56	-6.73	4	1	0.58	0.5273	0.22
TSB	3.46	-13.23	54	1	599.36	0.0000	0.92
CLA	3.06	-11.58	200	1	2,923.27	0.0000	0.94

NOTE:

CH – chinook, CM – chum, CO – coho, PK – pink, TSB – threespine stickleback, CLA – Pacific staghorn sculpin

n – sample size, df – degrees of freedom, F – F statistic, R² – coefficient of determination



NOTE: * Top shows salmonids; bottom shows non-salmonid species
 CH – chinook, CM – chum, CO – coho, PK – pink, TSB – threespine stickleback, CLA – Pacific staghorn sculpin

Figure 4.2-3: Log-transformed Length-weight Relationship of Total Catch Data in the Kitimat River Estuary

Because of high variance in the sample area among sites, total catch alone does not give a representative indication of relative abundance across sites and is of limited use in the interpretation of relative abundance over time (Table 4.2-2). Consequently, the results must be standardized and compared in terms of C_{PUA}. Mean standardized C_{PUA} among sites is presented for all species observed in the study in Table 4.2-7 and Figure 4.2-4. Table 4.2-8 lists the total catch per month in each site (T_c) and standardized catch per pass (C_i) for each site, along with calculated C_{PUA}. Figure 4.2-5 and Figure 4.2-6 display standardized relative abundances in the LSA in terms of C_{PUA} of combined catch by species and by month, respectively, among the four estuary sites. The relative abundance during spring of 2012 and 2013 shows the mean C_{PUA} for all species in each site where sampling took place between April 2012 and June 2013 (Figure 4.2-7).

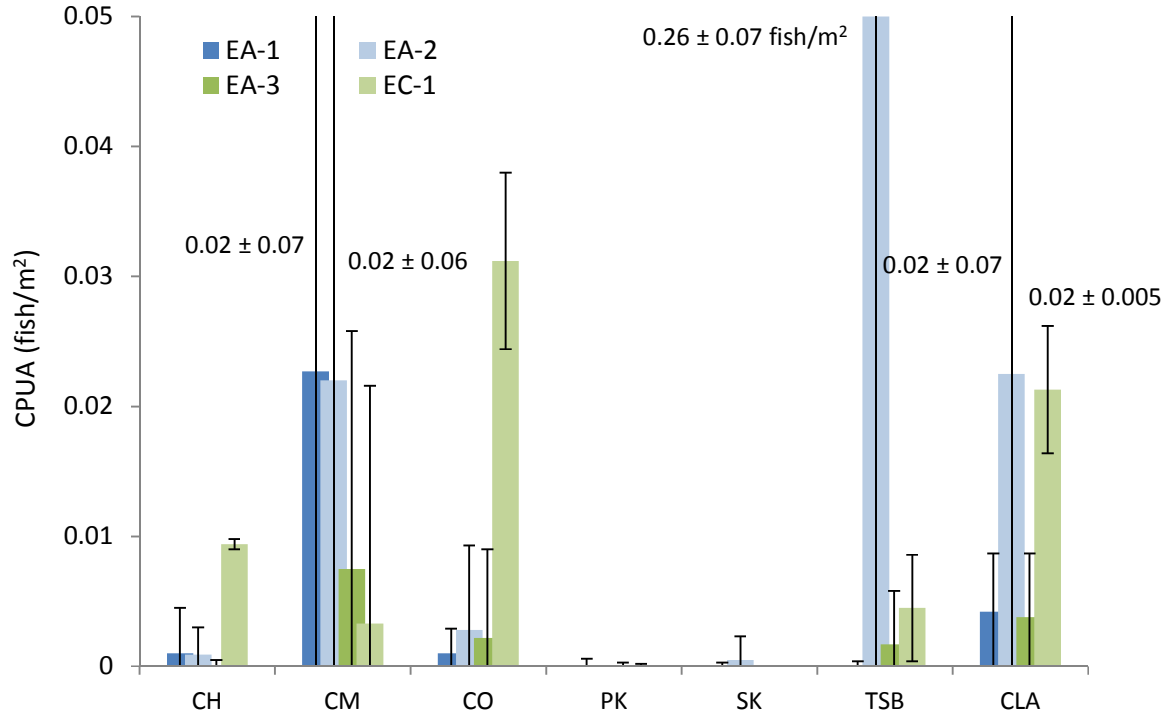
Table 4.2-7: Mean Standardized C_{PUA} by (Fish/m²) Species for each Estuarine Sampling Site

Species	EA-1		EA-2		EA-3		EC-1	
	mean	σ	mean	σ	mean	σ	mean	σ
CH	0.0010	0.0035	0.0009	0.0021	0.0001	0.0004	0.0094	0.0004
CM	0.0230	0.0730	0.0220	0.0630	0.0075	0.0183	0.0033	0.0180
CO	0.0010	0.0019	0.0028	0.0065	0.0022	0.0068	0.0310	0.0070
PK	0.0001	0.0005	0.0000	-	0.0001	0.0002	0.0000	0.0002
SK	0.0001	0.0002	0.0005	0.0018	0.0000	-	0.0000	-
TSB	0.0001	0.0003	0.2580	0.6780	0.0017	0.0041	0.0045	0.0041
CLA	0.0042	0.0045	0.0230	0.0710	0.0038	0.0049	0.0210	0.0050
SFL	0.0000	0.0001	0.0000	-	0.0000	-	0.0000	-

NOTES:

σ – standard deviation

CH – chinook, CM – chum, CO – coho, PK – pink, SK – sockeye, TSB – threespine stickleback, CLA – Pacific staghorn sculpin, SFL – starry flounder



NOTE: CH – chinook, CM – chum, CO – coho, PK – pink, SK – sockeye, TSB – threespine stickleback, CLA – Pacific staghorn sculpin, SFL – starry flounder

Figure 4.2-4: Mean Standardized CPUA by Site for all Species

Table 4.2-8: Standardized Monthly C_{PUA} (Fish/m²) for Combined Species by Site

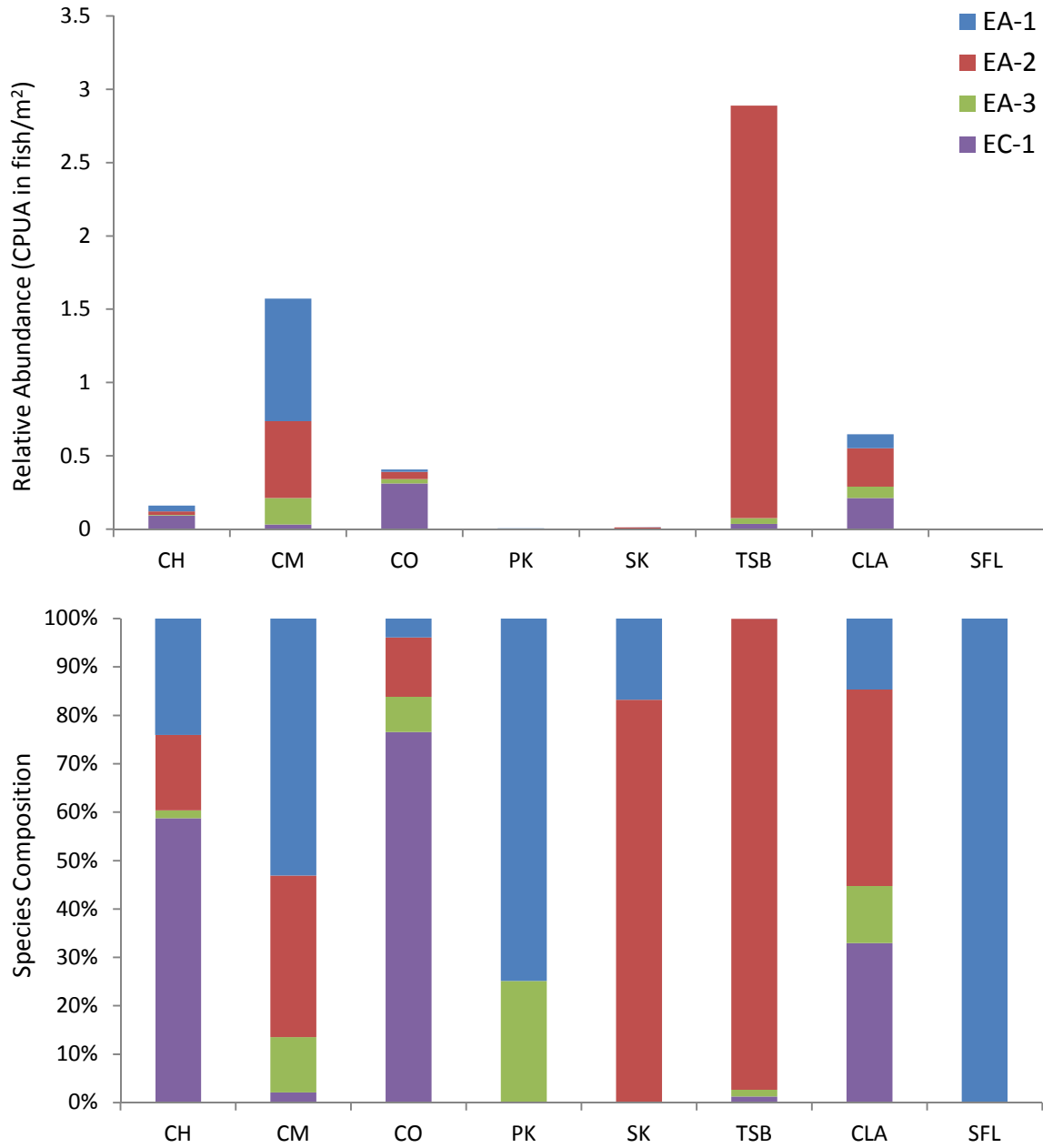
Month	T _c	C _i	mean	σ	T _c	C _i	mean	σ
	EA-1				EA-2			
Apr-12	20	20	2.10E-03	5.28E-03	0	0	0	0
May-12	1044	348	1.22E-02	3.08E-02	9	3	4.69E-03	7.19E-03
Jun-12	12	12	1.26E-03	3.56E-03	0	0	0	0
Sep-12	12	12	1.26E-03	3.24E-03	19	19	2.97E-02	8.40E-02
Oct-12	8	8	8.40E-04	1.80E-03	0	0	ND	ND
Nov-12	0	0	0	0	0	0	0	0
Dec-12	8	8	8.40E-04	1.80E-03	16	16	2.50E-02	6.58E-02
Jan-13	0	0	0	0	0	0	0	0
Feb-13	7	7	7.35E-04	2.08E-03	176	176	2.75E-01	7.68E-01
Mar-13	36	18	9.45E-04	1.76E-03	39	20	3.05E-02	7.38E-02
Apr-13	27	14	7.09E-04	2.01E-03	0	0	0	0
May-13	10	5	2.63E-04	7.43E-04	36	18	2.81E-02	7.70E-02
Jun-13	0	0	0	0	0	0	0	0
Apr-12	20	20	2.10E-03	5.28E-03	0	0	0	0
	EA-3				EC-1			
May-12	24	24	2.54E-03	5.55E-03	0	0	ND	ND
Jun-12	11	4	3.88E-04	6.39E-04	0	0	ND	ND
Sep-12	3	3	3.18E-04	8.99E-04	0	0	ND	ND
Oct-12	5	5	5.30E-04	1.01E-03	11	11	5.64E-03	1.14E-02
Nov-12	31	31	3.28E-03	8.62E-03	15	15	7.69E-03	1.21E-02
Dec-12	0	0	0	0	7	7	0	1.01E-02
Jan-13	0	0	0	0	0	0	0	0
Feb-13	1	1	0	3.00E-04	1	1	0	1.45E-03
Mar-13	2	2	2.12E-04	5.99E-04	0	0	0	0
Apr-13	76	38	4.03E-03	6.03E-03	3	2	3.84E-04	7.63E-04
May-13	162	81	8.58E-03	2.31E-02	20	10	2.56E-03	3.63E-03
Jun-13	55	28	2.91E-03	5.34E-03	101	51	1.29E-02	2.31E-02

NOTES:

Data are calculated given total catch (T_c) and catch per set (C_i) during the study period

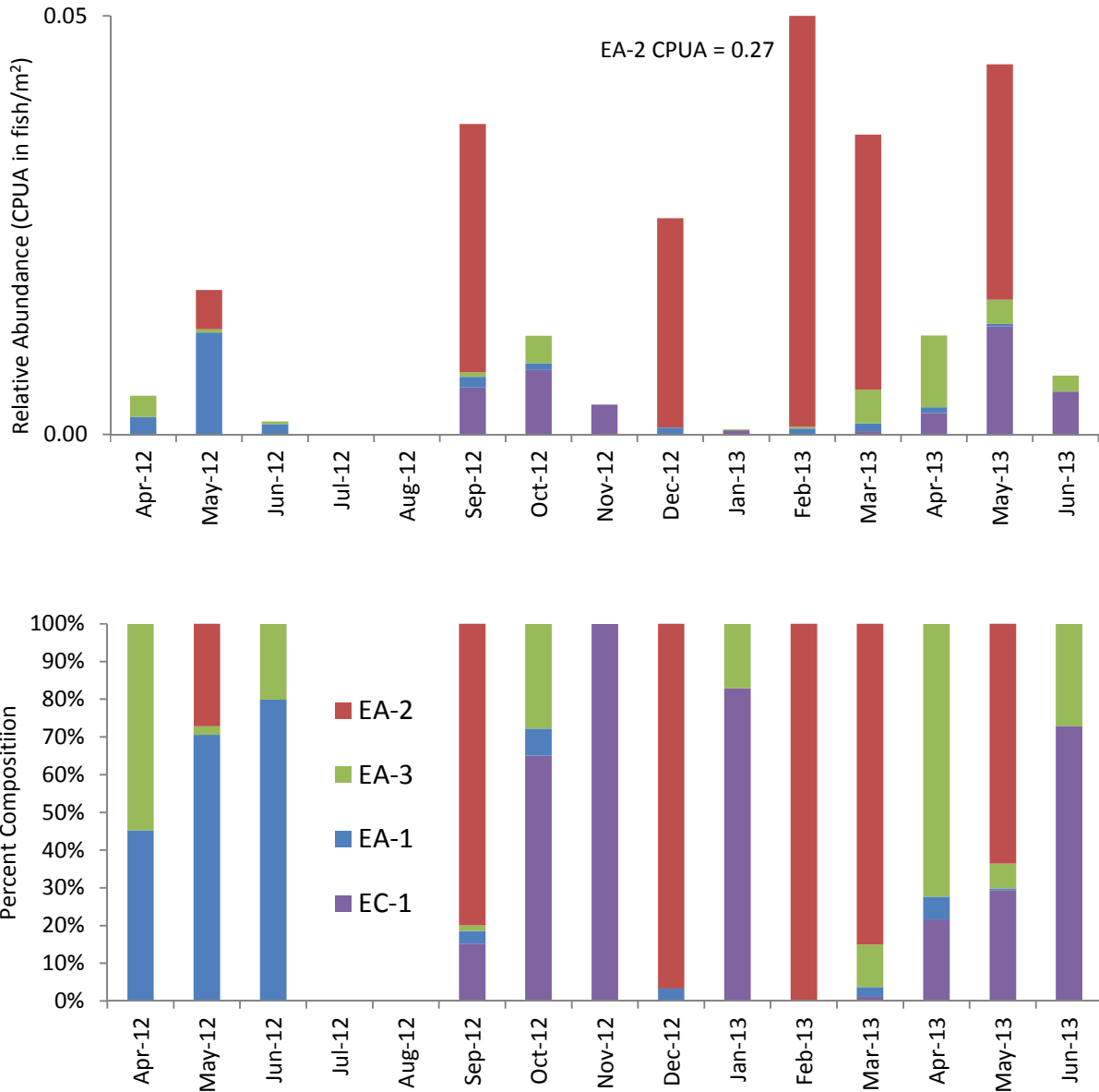
σ standard deviation

ND – no data



NOTE: CH – chinook, CM – chum, CO – coho, PK – pink, SK – sockeye, TSB – threespine stickleback, CLA – Pacific staghorn sculpin, SFL – starry flounder

Figure 4.2-5: Standardized Relative Abundance by Species for all Sites

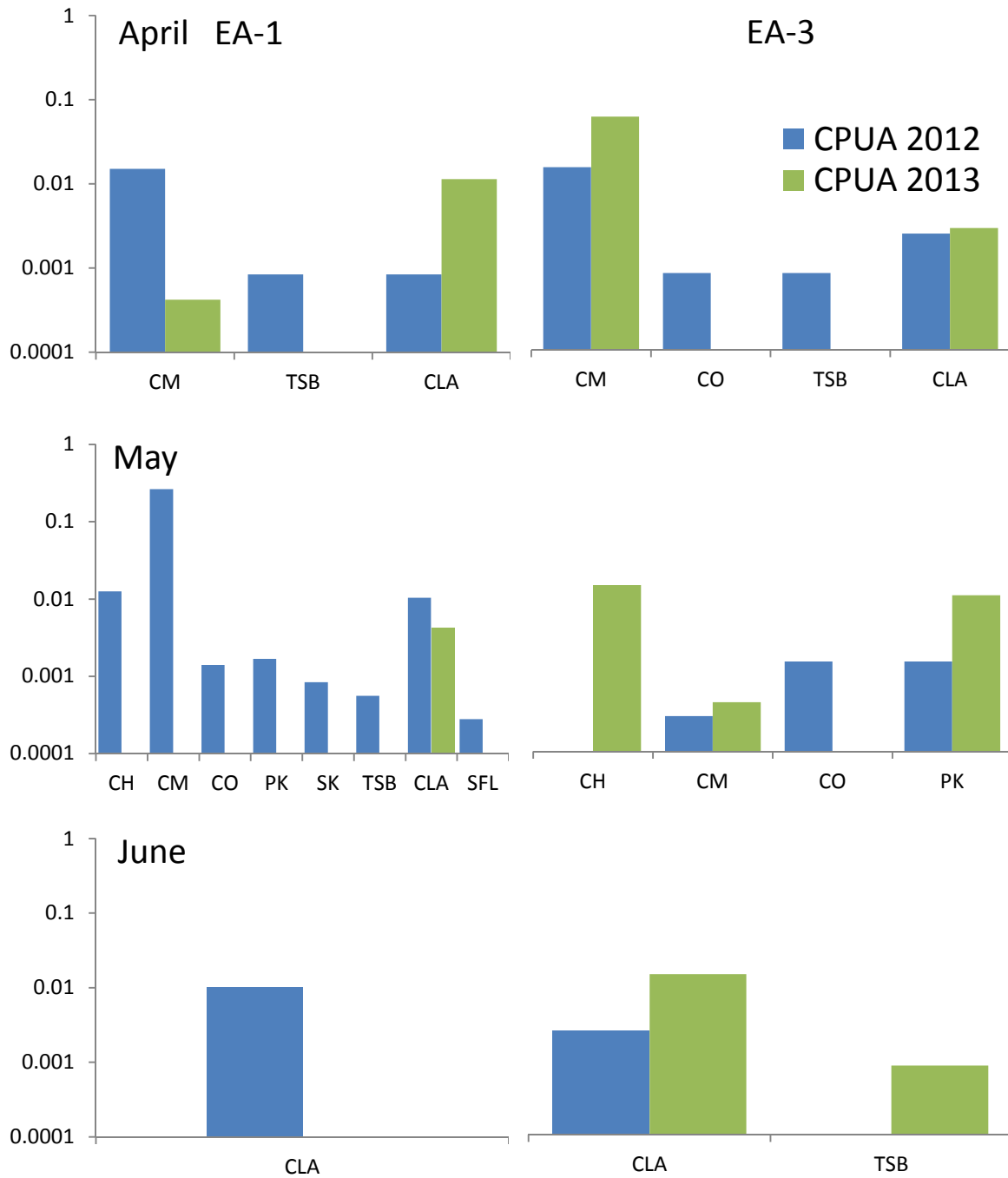


NOTES: February 2013 values are out of range; values has been displayed as a label

a = Sampling did not occur in July or August 2012

CH – chinook, CM – chum, CO – coho, PK – pink, SK – sockeye, TSB – threespine stickleback, CLA – Pacific staghorn sculpin, SFL – starry flounder

Figure 4.2-6: Monthly^a Standardized Relative Abundance and Fish Distribution by Site



NOTES: * Data are displayed as log-scale. Site EA-1 is shown on the left and Site EA-3 is shown on the right
 CH – chinook, CM – chum, CO – coho, PK – pink, SK – sockeye, TSB – threespine stickleback, CLA – Pacific staghorn sculpin,
 SFL – starry flounder

Figure 4.2-7: Inter-annual Variation in CPUA (fish/m²) by Species

4.2.3 Discussion

Generally, results indicate that estuarine tidal channels are important habitat for all species of juvenile Pacific salmon. Non-salmonid species are also present in estuarine tidal channels including threespine stickleback and Pacific staghorn sculpin, both commonly observed over the duration of the survey and across sites. The presence of multiple age classes of threespine stickleback and Pacific staghorn sculpin also indicates that such estuarine habitats are perennially occupied by these smaller, non-migratory fishes. Starry flounder were not observed in significant numbers. Throughout the survey, only a single fish was caught in May 2012 at Site EA-1 and a second fish was observed dead in September 2012 near the entrance of Site EC-1; these were the only estuarine observations. It is possible that the narrow tidal channels sampled become less suitable habitat for starry flounder compared to the larger, open, flat bottoms of the main estuary channels. Site conditions of the smaller estuarine channels have been discussed and site photos have been included in Appendix E.

Juvenile Pacific salmon use estuarine habitats during early life stages. Pink and chum salmon both migrate to estuaries upon fry emergence in the spring. Chum salmon was the most abundant salmonid overall with the highest densities in the spring (March to May; see Appendix D, Table D-2) that correspond to emigration from natal freshwater streams. Pink salmon was also present, but not as well represented, likely because of the mesh size of the stop net; some pink fry may have been small enough to escape through the mesh. Young-of-year and smolts of coho, chinook, and sockeye were also observed in the study area. Coho salmon was the only species to be observed outside of spring months. This is to be expected given the predominance of juvenile coho observed in freshwater habitats directly upstream and could also result from periodic high runoff events during both spring and fall freshets displacing them from freshwater habitats.

Chinook salmon caught during surveys appeared to represent at least two age classes. Smolts (age 1+) likely accounted for most of the captured. It is difficult to ascertain ages for the chinook observations given there are two ecotypes of chinook found in the Kitimat River (McPhail 2007). Kitimat River chinook represent a mix of the more dominant ocean-type and a reduced proportion of stream-type (88% and 12% respectively; Healey 1983). Ocean-types migrate to sea in their first year and grow much faster than river-types, which remain in freshwater systems for one or two years before seaward migration (McPhail 2007). Triton did not examine age structures in the study, but the catch data consisted of a mix fry and smolts, likely from both ecotypes based on the length frequency data (Figure 4.2-2).

The few sockeye salmon fry (mean length 35 ± 11 mm; $n = 3$) observed in May 2012 might have been prematurely flushed out of Anderson Creek or the Kitimat River because river-type sockeye, which have been reported in Anderson Creek and the Kitimat River, tend to overwinter for one year and remain in freshwater sloughs, beaver ponds, and along river margins in still waters before migrating to sea

(McPhail 2007). Minimal presence of sockeye (i.e., four fish were observed in the entire study) suggests Kitimat River sockeye may not make as much use of estuarine tidal channels upon migration to sea.

Morphometric Analysis

Regression analyses were statistically significant ($\alpha = 0.05$) for all species except pink salmon. This is not surprising because only four pink salmon were observed and measured. The range of values for the slope parameter b was between 2.98 and 3.46. Invariably, b tends to be close to 3.0 for all fish species (Schneider et al. 2000). Different species within the family Salmonidae have more subtle differences in a and b . Comparisons within a single species are even more subtle and vary according to the condition of individual fish. Condition can reflect food availability (Schneider et al. 2000) or other factors like disease or environmental stressors. Monitoring these parameters can offer helpful comparisons within and among species that are examined over time and in conjunction with other environmental variables that could be affected by the Project.

Standardized CPUA

Temporal changes in relative abundance commonly reflect life history stages; this is most relevant for anadromous salmonids during annual seaward migration. The decision to double sampling effort during spring months and repeat the protocol over two years was based on this rationale.

Across sites, results showed that chum salmon had the highest densities among salmonids, followed by coho salmon. Chum salmon only appeared in the estuary during the spring months associated with fry out-migration and disproportionately so in Site EA-1 during May 2012. Given the widespread distribution of coho salmon upstream in the LSA, it was not surprising that coho salmon had a relatively stronger presence than other Pacific salmon in the LSA and across more seasons. Chinook salmon was the third most abundant species and was more consistently observed in the control site EC-1.

As for non-salmonids, threespine stickleback is most abundant, followed by Pacific staghorn sculpin; however, mean estimates have fairly wide confidence intervals (Table 4.2-6; Figure 4.2-4), indicating a high degree of seasonal variation. Threespine stickleback was disproportionately concentrated in Site EA-2 in February and March (see Appendix D, Table D-2) and Triton observed evidence of spawning colouration during these trips, indicating that Site EA-2 may be more suitable spawning habitat. Pacific staghorn sculpin were less abundant than threespine stickleback, but were observed to be more evenly distributed across sites (Figure 4.2-5).

The final analysis in this study examined inter-annual variation in species between two potentially affected sites (EA-1 and EA-3). This helped to assess changes in the use of estuary tidal channels by Pacific salmon during spring in two consecutive years. The two sites are comparable in size, but differ in terms of the quality of habitat and accessibility.

Results showed inter-annual variation to be higher in Site EA-3 during April, but highest overall in EA-1 during May. Inter-annual variation was the lowest in June and did not differ between sites. Only chum salmon were present in Site EA-3 in April 2013 compared to both chum and coho observed in 2012. Chum was the only species of salmon present in EA-1 during April for both years. Inter-annual variation in May was most pronounced in EA-1, both in terms of number of species represented and overall fish. No Pacific salmon were observed in May of 2013 in EA-1 compared to four species the year earlier (Figure 4.2-7). This may be due to unique physical attributes of Site EA-1, which includes inaccessibility due to the presence of the wharves. In June, no salmonids were present in either year, indicating the spring juvenile out-migrations into estuary habitats have mostly concluded by this time.

The estuarine fish and fish habitat survey yielded a high degree of spatial and temporal variation due to low densities observed. The comparison of standardized CPUA has limited utility given added variation in site properties. To reduce unnecessary variation, the area of the sites could be more comparable in size, and sampling could be more consistently timed across all months. This is problematic to effectively plan for in winter months, given the short day lengths and limited windows for sampling. Unique physical and chemical properties of Site EA-1 have likely resulted from the construction of the wharves, which have reduced its utility as estuarine habitat for anadromous species that occupy freshwater habitats upstream in the LSA and in the Kitimat River in general.

Site EA-1

Site EA-1 is located between two long wharves that extend out into Douglas Channel. This poses an obstruction to fish movement along the shoreline and effectively isolates the site from the rest of the estuary. Estuarine habitat in EA-1 is thus relatively inaccessible compared to the other sites. Site EA-1 also had higher mean salinity and temperature data along with depressed DO and ORP levels compared to other sites. The salinity levels are likely a result of the wharves restricting runoff from flooding the site during periods of high precipitation and elevated stream discharge. Higher temperatures and lower DO may also be partly a result of the enclosed nature of the site, which has likely affected its physical characteristics. Compared to all other sites, EA-1 had the greatest accumulation of LWD along the littoral zone and more evidence of intertidal flora (e.g., *Fucus* spp.). It has the shallowest channel, which could have elevated ambient water temperature compared to other sites. Despite all of these factors, the full range of species found in the estuary component of this study was observed in Site EA-1 during May 2012.

Overall catch data for chum salmon were skewed by an exceptionally high number of fry (945 fish) retained in Site EA-1 in May 2012. Triton only measured a subsample of the catch (mean length of 48 ± 6 mm; $n = 20$), but the massive aggregation likely represented a single cohort since the timing corresponds with delayed sea migrations for chum at higher latitudes (Godin 1982). Chum fry spend

prolonged periods feeding in estuaries on detritus (Salo 1991), which is most abundant in Site EA-1 compared to the deep and rather simple morphology in the channels of other sites.

Pacific staghorn sculpin is abundant in Site EA-1 with numerous age classes represented. At low tides, wetted areas upstream of the stop net location still contained numerous fish, although use of pole-seines allowed for an increase in the total catch per set. Pacific staghorn sculpin is predominantly a marine species compared to other sculpins observed in the freshwater component (although Pacific staghorn sculpin were also found in freshwater habitats). Based on salinity values and given the restriction by the wharves, Site EA-1 has more marine-like conditions compared to other sites. Like Pacific staghorn sculpin, starry flounder is also a predominantly marine species and was only observed in Site EA-1. Starry flounder and Pacific staghorn sculpin are likely to be unaffected by the more marine-like condition of EA-1, but other species that rely on brackish waters and accessibility to freshwater habitats may be affected, such as threespine stickleback and coho salmon fry.

Coho salmon is ubiquitous to the freshwater habitats in the LSA upstream of the estuary. Perhaps due to difficulty getting around the wharves, only a handful of coho (fry and age 1+) were apparently able to enter Site EA-1 over the study period. In May 2012, all fish captured were likely age 1+ (mean length 83 ± 5 mm; $n = 5$) whereas the catch in October contained the most coho of any month, as a mix of fry and age 1+ (mean length 51 ± 18 mm; $n = 6$). The October 2012 sampling event took place immediately after a period of heavy rains and high runoff. Coho fry likely moved offshore along the freshwater surface lens into Douglas Channel, around the wharves, and back into the site. These fish could easily become trapped by the rising salinity as freshwater inputs subsided. Coho fry captured in October were impinged by debris in the stop net when it was pulled and died during the enumeration and measurement processes. This is an indication of physiological strain, possibly due to the osmotic stress from high salinity. Dissolved oxygen levels were also depressed (43.5% and 4.93 mg/L) during this sampling event; Site EA-1 had the lowest oxygen levels overall (41.4% or 4.34 mg/L in May 2012).

Site EA-2

This site is small in area compared to the other sites. The short channel also has much coarser substrate (e.g., gravels mixed with small and large cobbles). Unlike the other sites, it also drops abruptly from an upstream meadow rather than having a long, gradually tapering channel and appears more likely to have been excavated out at an earlier point in time. Site EA-2 contained predominantly overwintering threespine stickleback in 2013. A single chum salmon arrived in May of both years and Pacific staghorn sculpin was observed in September 2012. A handful of other fish caught included a single sockeye and three coho salmon in March 2013, and a coho salmon in December 2012. The small area of Site EA-2 (80 m² vs. 1,200 m² for EA-1 and EA-3) substantially inflated the fish density in terms of standardized CPUE, which has made its importance to fish over winter appear high.

Site EA-3

Site EA-3 is a representative tidal channel in the LSA. It is not obstructed by any wharf and opens into a large, blind estuary channel, which is blocked off at the upper end by a constructed dike. This dike near the transmission tower confines Reach 1 of Moore Creek in the Dike Area (Section 4.1.3.1, Appendix A, Figure A-3). The dike has restricted the estuary channel from all freshwater inputs in the LSA. Fish that are flushed out of the upstream freshwater system by high precipitation and runoff must navigate the adjacent large estuarine channel to the east downstream to its mouth at Douglas Channel. Once in open water, the fish must head up the adjacent large channel to access Sites EA-2 and EA-3. Of these two sites, EA-3 is a longer migration, but high numbers of coho salmon were captured in this site in October 2012 following the heavy rain events. Site EA-2 had no coho salmon suggesting that coho prefers the habitat characteristics of EA-3. It is also possible that the dike prevents juvenile coho from retreating back into Moore Creek and associated freshwater habitats. As a result, these fish would tend to remain concentrated in the upper portion of large estuary channel where site EA-3 is located.

Results also show EA-3 to be more consistent habitat for migrating juvenile Pacific salmon compared to EA-1 during the spring months (April through June) between 2012 and 2013 (Figure 4.2-7). In 2012, all species were observed in Site EA-1, whereas only chum were evident in 2013. On the other hand, EA-3 had fewer salmon species represented in 2012 (chum, coho, and pink), but was relatively more consistent in terms of the number of species represented in both years. It is unknown whether some unique condition has allowed for the unusually high numbers of salmon species (especially chum) observed in Site EA-1 in 2012, compared to the lack of species observed in 2013. Based on the skewed concentration of chum relative to all other species in EA-1, it seems plausible that May 2012 may have been an anomaly. In either case, Site EA-3 appears to be a more stable estuarine environment with less inter-annual variation compared to EA-1.

Site EC-1

The control site in Minette Bay provided a useful comparison of species composition with the main estuarine portion of the LSA. Minette Bay is subject to a wide range of freshwater inputs, including numerous streams that drain from the east and likely support distinct salmon runs. Site EC-1 was not introduced to the study until the September 2012 visit, but monthly results show Site EC-1 to be important in terms of overall standardized CPUA (Figure 4.2-6). Site EC-1 is most comparable in morphology to EA-3, although smaller in size (approximately 250 m² compared to 1,200 m² for EA-3). Chinook and coho salmon are more abundant in EC-1; the most notable observation in this site was high density of fry and age 1+ coho in May 2013, which are likely to have migrated in during a high precipitation event. Sampling directly followed a major runoff event that likely flushed young coho out of the upstream freshwater habitats (Figure 4.2-6). High numbers of coho in EC-1 were not replicated in other sites, including EA-3,

which had the highest densities of coho in October 2012 following a fall rain event. This concurs with the high degree of variation observed in the distribution and abundance of fish throughout the LSA (Figure 4.2-4). It also makes factors like periodic flushing events less predictable in terms of the effects on fish distribution in freshwater and estuarine habitats.

5 MODELLING

Based on the results of this baseline investigation of freshwater and estuarine fish and fish habitat, an empirical habitat evaluation procedure was employed to determine the amount of wetted habitat subject to potential effects. This technical effects assessment is based on the species and habitats identified in the TDR and deemed to be representative of fisheries productivity in the aquatic ecosystem. The emphasis of the series of quantitative analyses is on spatial and seasonal use of the freshwater habitats identified in the LSA. Estimation of productivity is intended to support a mandatory authorization under Paragraph 35 (2)(b) of the federal *Fisheries Act*, based on the environmental assessment. Productivity has been determined through an examination of habitat suitability, given fish distribution, and has involved distinct analytical approaches for the estimation of mainstem and off-channel aquatic fish habitats.

The effects assessment report (Triton 2014) has been included in this TDR as Appendix F.

6 CONCLUSIONS

A baseline examination of freshwater and estuarine fish and fish habitat for the Project revealed new information about fish production in the LSA. The spatial analysis of both fish and fish habitat necessarily considers effects from pre-existing industrial developments and associated infrastructure, as well as deliberate attempts to influence drainage patterns in the local study areas. Such activities have brought these freshwater and estuarine aquatic ecosystems to their present states.

Coho salmon is the most abundant and widely distributed species in freshwater mainstem and off-channel habitats of Anderson Creek, Beaver Creek, and Moore Creek. Off-channel habitat west of the Kitimat River also supports juvenile coho salmon. Pacific salmon species observed spawning in Anderson Creek included coho, chum, pink, and sockeye. Coho salmon also spawns in Moore Creek and likely to spawn in upper Beaver Creek, although this was not directly observed in the study.

Lower Beaver Creek is subject to extensive surface and subsurface inputs from Anderson Creek. It has excellent rearing and overwintering conditions for coho salmon. Perennial side channels improve accessibility from Anderson Creek to rearing and overwintering habitats in Beaver Creek for Pacific salmon, including coho and chinook. Non-anadromous salmonid species found in the local study areas include rainbow trout and Dolly Varden. Non-salmonid species include threespine stickleback, lamprey, and several sculpin species that occupy both mainstem and side channel habitats. Stickleback is the most abundant non-salmonid species to occupy these freshwater habitats and favours off-channel habitat in Anderson Creek and slower moving mainstem habitats with abundant cover. Although historically important to Haisla Nation, eulachon was not detected in any part of the local study area during this assessment, including the off-channel habitats of Kitimat River West.

Fish densities in mainstem freshwater habitats are seasonally affected by changes in stage of stream discharge. Results demonstrate that coho salmon and threespine stickleback typically make extensive use of off-channel habitats that become seasonally available during periods of increased runoff. Declining abundance at higher flows in mainstems and perennial side channels indicates that fish rely on ephemeral off-channel habitats during peak flows. Ephemeral habitats become less important and possibly detrimental to fish during seasons of reduced flow, due to dewatering and risk of stranding. Dissolved oxygen is also a principal determinant of fish distribution in the auxiliary off-channel habitats and extensive wetland complexes in the LSA.

Estuarine habitats located downstream of the freshwater system are important in spring during annual seaward migrations of Pacific salmon, particularly for chinook and chum, but less so for pink and sockeye. Coho salmon use the estuarine tidal channels during periods of high runoff and associated flushing events throughout the year. The dispersion of fish in the Kitimat River estuary is non-uniform and exhibits

a high degree of spatial and temporal variability, which makes it difficult to predict how both industrial development and natural environmental processes will influence fish use. Threespine stickleback and Pacific staghorn sculpin occupy the tidal channels during multiple life stages and at least one such site in the estuary appears to be important spawning habitat for stickleback. It is not clear from this baseline investigation whether seasonal interplay between freshwater and estuarine habitats exists for stickleback. The stable presence of sculpins in estuary tidal channels can be a useful monitoring tool in environmental management. Other diagnostic tools for monitoring include morphometric data collection and sustained water quality monitoring. These improve the understanding of environmental factors that influence the distribution of fish in the estuary and should complement similar efforts in upstream freshwater habitats.

7 CLOSURE

The information presented in this TDR should be treated as a baseline description of freshwater and estuarine fish and fish habitat in the LSA for the LNG Canada Export Terminal. It is appropriate for the assessment of potential effects and the development of mitigation and offsetting measures acceptable under the provincial *Fish Protection Act* and the federal *Fisheries Act*. The results should be used to develop an appropriate level of aquatic effects monitoring under a clearly defined environmental management plan that can effectively guide the development process.

Respectfully submitted,

Triton Environmental Consultants Ltd.



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8.2 Personal Communications

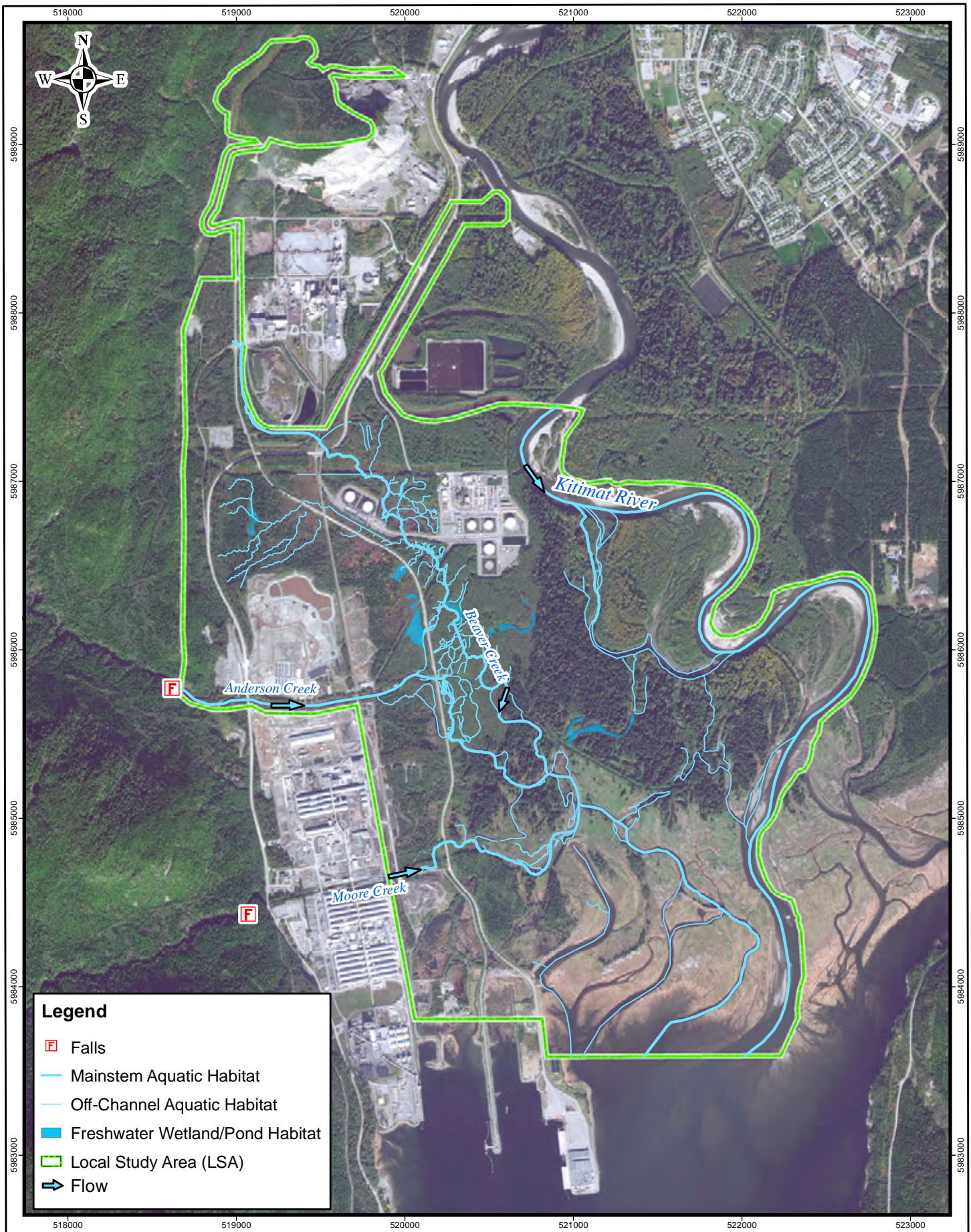
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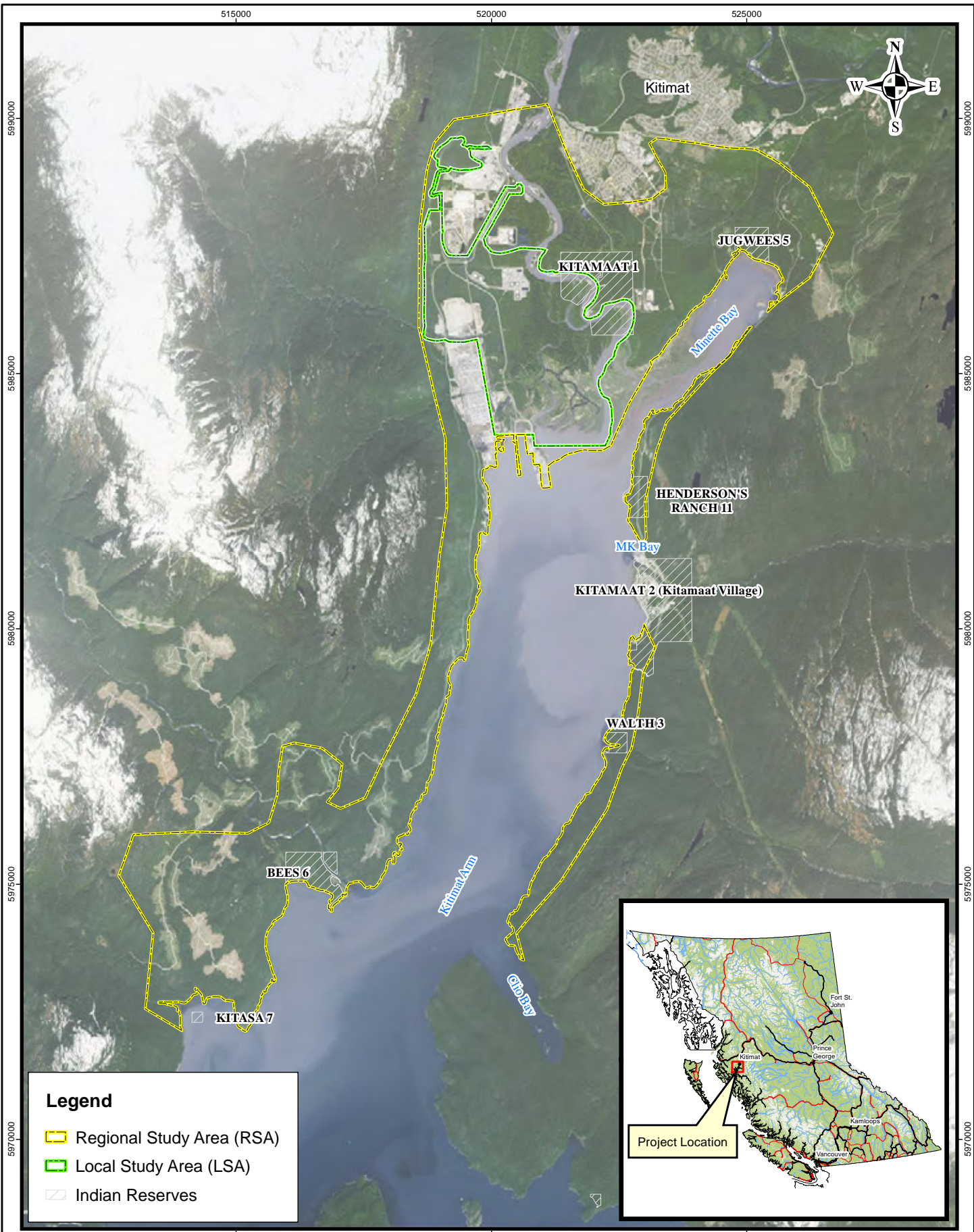
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APPENDIX A

Maps of Study Area





Legend

- Regional Study Area (RSA)
- Local Study Area (LSA)
- Indian Reserves

LNG CANADA
 Opportunity for British Columbia. Energy for the world

Basemap Source:

Orthophoto

0.75 0.95 0 0.75 1.5 2.25 3 Kilometers

Scale: 1:100,000

Map Datum:

UTM NAD 83 Zone 9

Appendix A, Figure A-2: Regional Study Area Overview Map

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6018

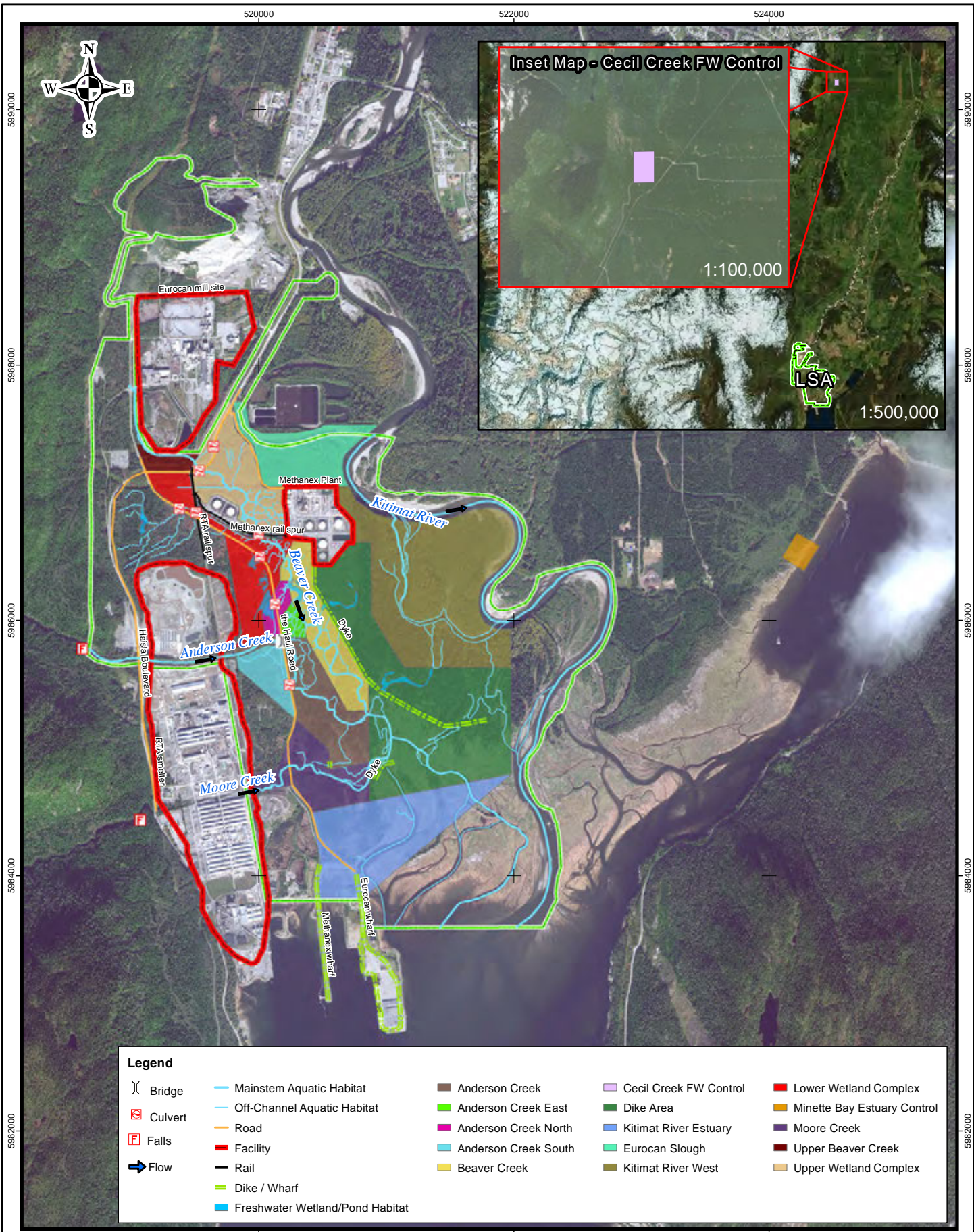
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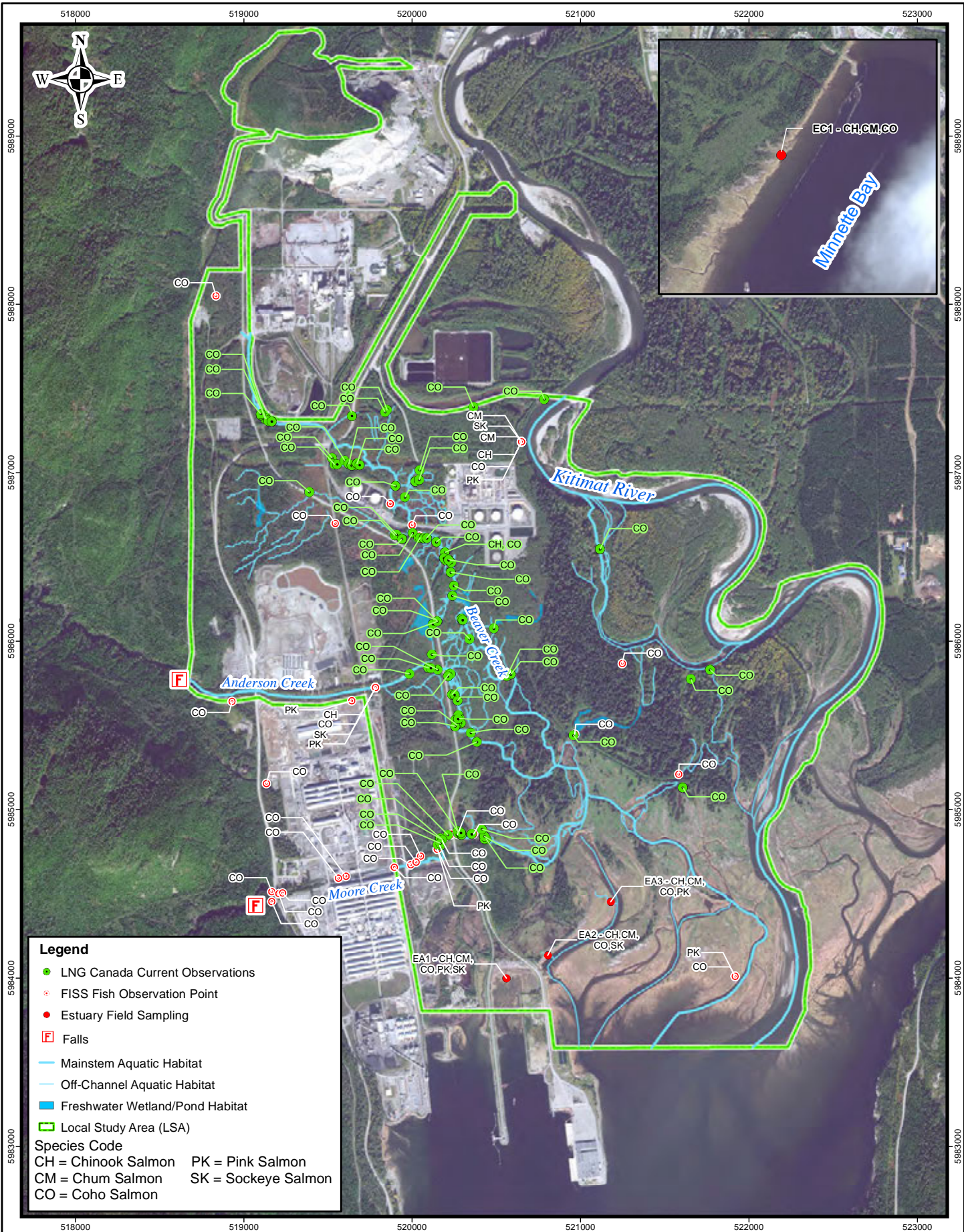
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Date:

Aug 15, 2014

TRITON
 ENVIRONMENTAL CONSULTANTS LTD.





Basemap Source:

Orthophoto



Scale: 1:30,000

Map Datum:

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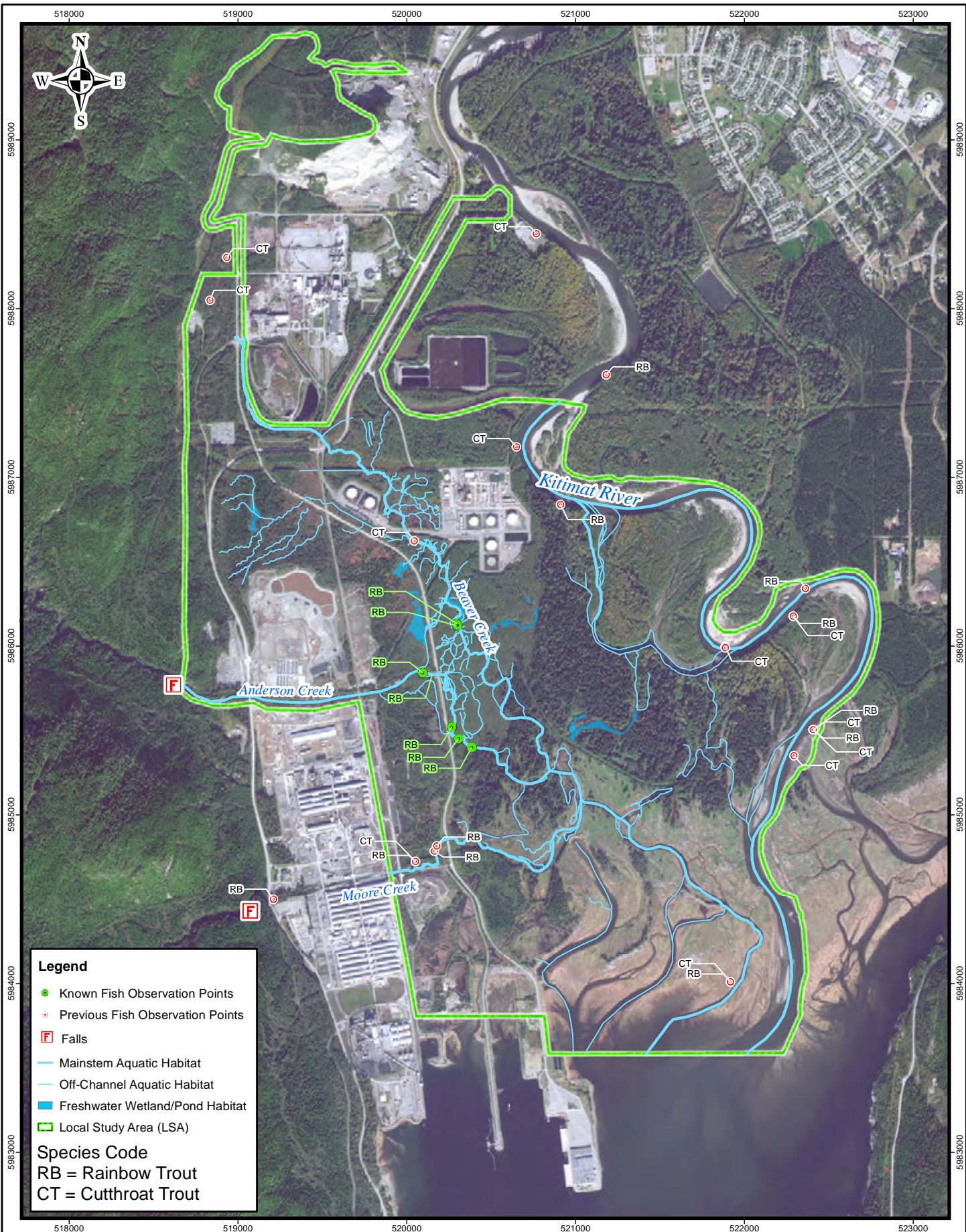
Appendix A, Figure A-4: Previous & Known Observations of Pacific Salmon Species

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6018

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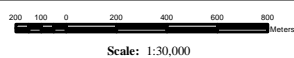
Legend

- Known Fish Observation Points
- Previous Fish Observation Points
- F Falls
- Mainstem Aquatic Habitat
- Off-Channel Aquatic Habitat
- Freshwater Wetland/Pond Habitat
- Local Study Area (LSA)

Species Code
 RB = Rainbow Trout
 CT = Cutthroat Trout



Basemap Source:
Orthophoto



Map Datum:
UTM NAD 83 Zone 9

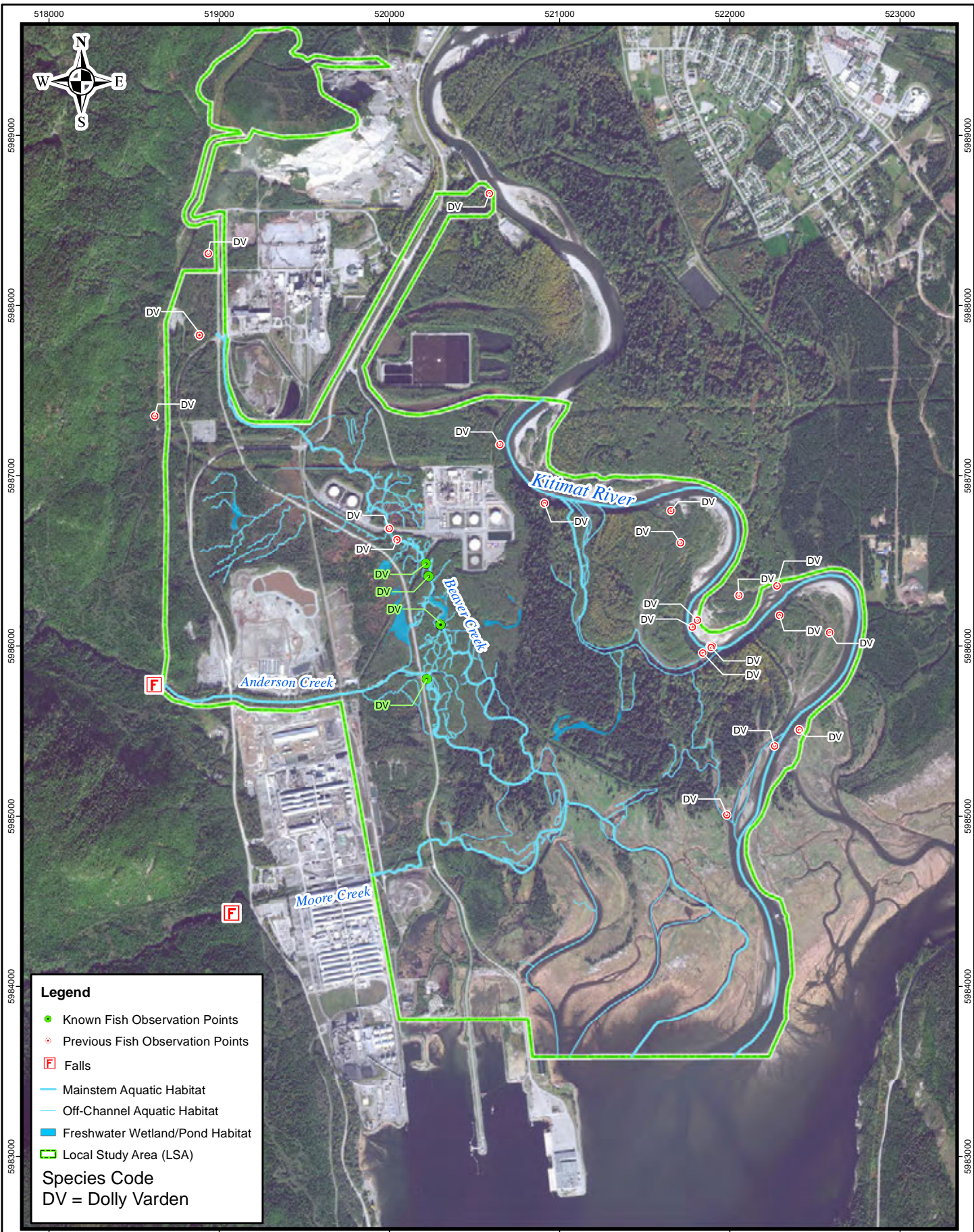
Appendix A, Figure A-5: Previous and Known Observations of Trout Species

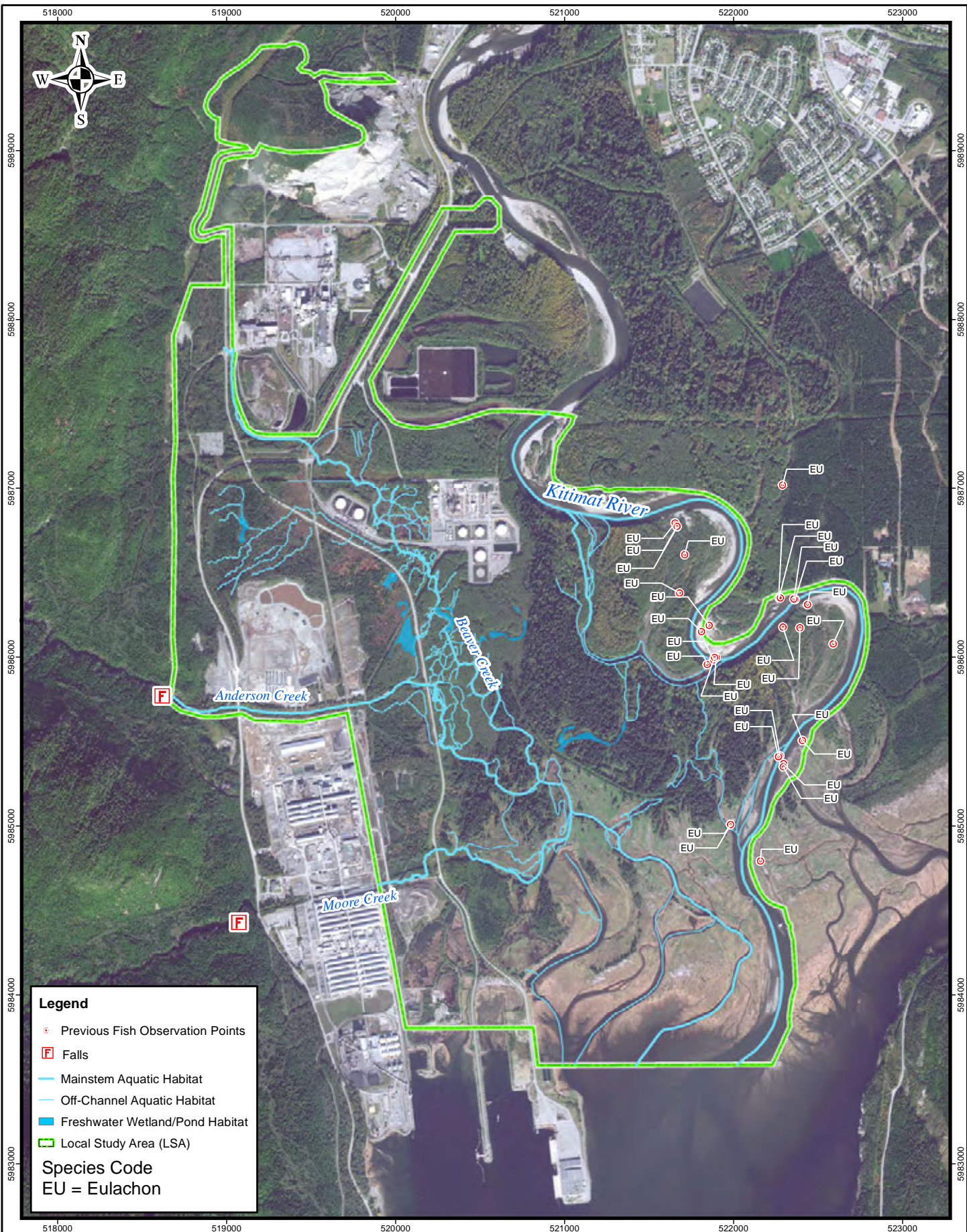
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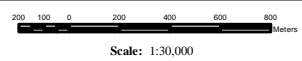
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- ⊙ Previous Fish Observation Points
- F Falls
- Mainstem Aquatic Habitat
- Off-Channel Aquatic Habitat
- Freshwater Wetland/Pond Habitat
- Local Study Area (LSA)

Species Code
EU = Eulachon



Basemap Source:
Orthophoto



Map Datum:
UTM NAD 83 Zone 9

Appendix A, Figure A-7: Previous & Known Observations of Eulachon

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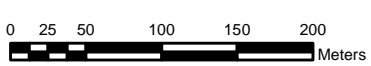
Date:
Aug 15, 2014





Appendix A, Figure A-8: Anderson Creek Mainstem Habitat Map May 2012

NO.	DATE (yyyy/mm/dd)	REVISION	BY
1	2013/19/08	Initial Draft	DP



Scale: 1:5,000

- Legend**
- Pool
 - Run
 - Riffle

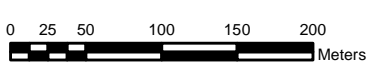


Basemap Source: Orthophoto		Map Datum: UTM NAD 83 Zone 9	
Project No: 6018	File No: Map#: N:\ACTIVE\6018_Kitimat_Creeks\MXD\Habitat_Aug16_13.mxd	Date: Aug 15, 2014	TRITON ENVIRONMENTAL CONSULTANTS LTD.



Appendix A, Figure A-9: Anderson Creek Mainstem Habitat Map June 2012

NO.	DATE (yyyy/mm/dd)	REVISION	BY
1	2013/19/08	Initial Draft	DP



Scale: 1:5,000

- Legend**
- Pool
 - Run
 - Riffle

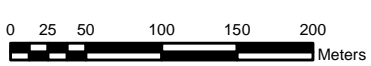


Basemap Source: Orthophoto		Map Datum: UTM NAD 83 Zone 9	
Project No: 6018	File No: Map#: N:\ACTIVE\6018_Kitimat_Creeks\MXD\Habitat_Aug16_13.mxd	Date: Aug 15, 2014	TRITON ENVIRONMENTAL CONSULTANTS LTD.



Appendix A, Figure A-10: Anderson Creek Mainstem Habitat Map September 2012

NO.	DATE (yyyy/mm/dd)	REVISION	BY
1	2013/19/08	Initial Draft	DP



Scale: 1:5,000

Legend

- Pool
- Run
- Riffle

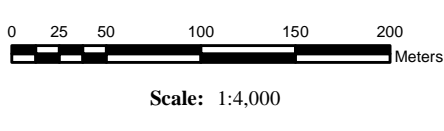


Basemap Source: Orthophoto		Map Datum: UTM NAD 83 Zone 9	
Project No: 6018	File No: Map#: N:\ACTIVE\6018_Kitimat_Creeks\MXD\Habitat_Aug16_13.mxd	Date: Aug 15, 2014	TRITON ENVIRONMENTAL CONSULTANTS LTD.



Appendix A, Figure A-11: Beaver Creek Mainstem Habitat Map May 2012

NO.	DATE (yyyy/mm/dd)	REVISION	BY
1	2013/19/08	Initial Draft	DP



- Legend**
- Pool
 - Run
 - Riffle

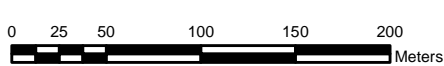


Basemap Source: Orthophoto		Map Datum: UTM NAD 83 Zone 9	
Project No: 6018	File No: Map#: N:\ACTIVE\6018_Kitimat_Creeks\MXD\Habitat_Aug16_13.mxd	Date: Aug 15, 2014	TRITON ENVIRONMENTAL CONSULTANTS LTD.



Appendix A, Figure A-12: Beaver Creek Mainstem Habitat Map June 2012

NO.	DATE (yyyy/mm/dd)	REVISION	BY
1	2013/19/08	Initial Draft	DP



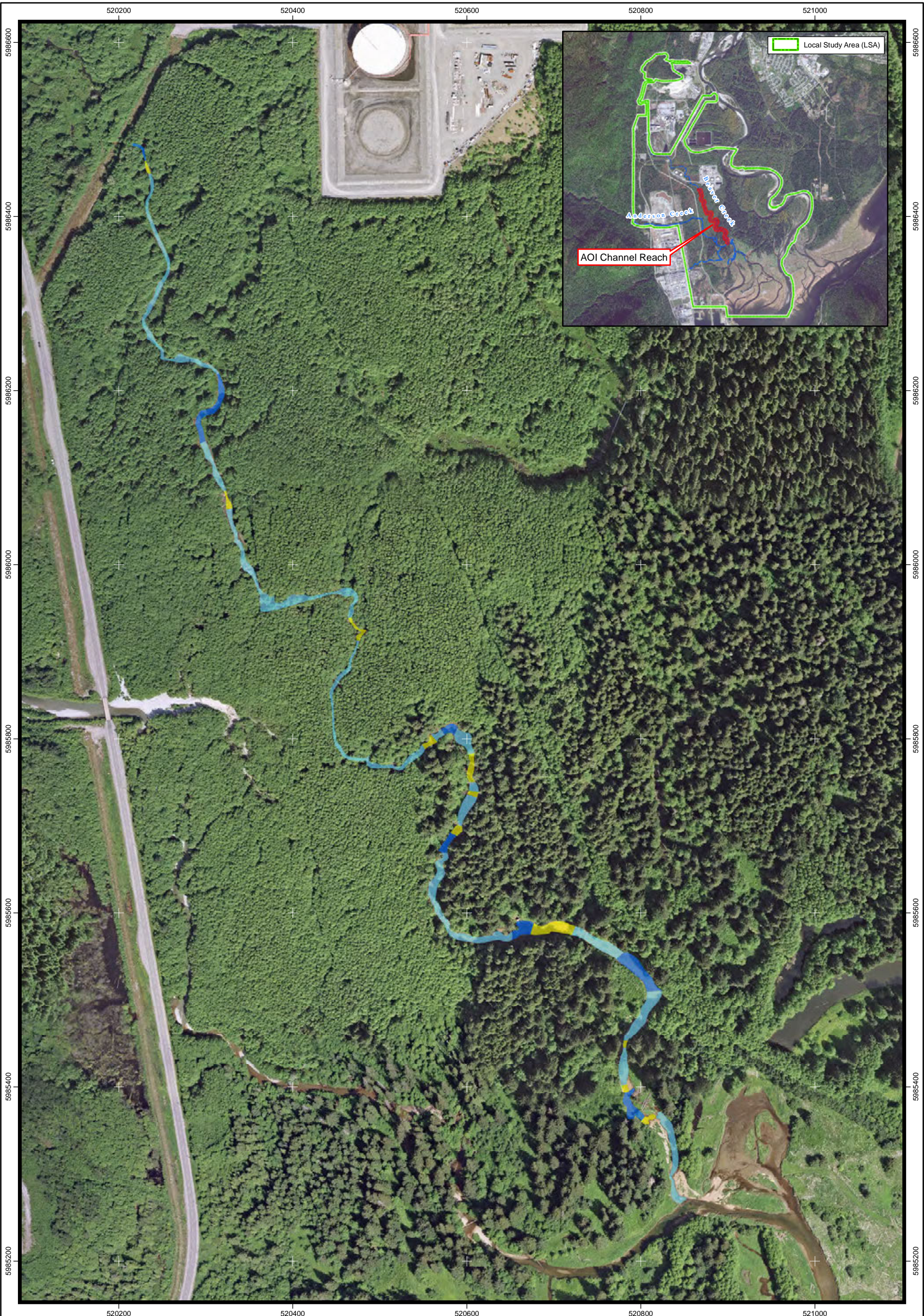
Scale: 1:4,000

Legend

- Pool
- Run
- Riffle

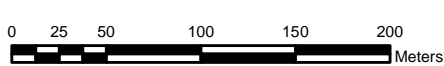


Basemap Source: Orthophoto		Map Datum: UTM NAD 83 Zone 9	
Project No: 6018	File No: Map#: N:\ACTIVE\6018_Kitimat_Creeks\ MXD\Habitat_Aug16_13.mxd	Date: Aug 15, 2014	TRITON ENVIRONMENTAL CONSULTANTS LTD.



Appendix A, Figure A-13: Beaver Creek Mainstem Habitat Map September 2012

NO.	DATE (yyyy/mm/dd)	REVISION	BY
1	2013/19/08	Initial Draft	DP



Scale: 1:4,000

- Legend**
- Pool
 - Run
 - Riffle



Basemap Source: Orthophoto		Map Datum: UTM NAD 83 Zone 9	
Project No: 6018	File No: Map#: N:\ACTIVE\6018_Kitimat_Creeks\MXD\Habitat_Aug16_13.mxd	Date: Aug 15, 2014	TRITON ENVIRONMENTAL CONSULTANTS LTD.

APPENDIX B

Background Fisheries Data



1308 – 1030 W. Georgia Street
Vancouver, BC V6E 2Y3

Phone 604 631 2211
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Table B-1 – Pre-existing Fish Capture Data in Project Watercourses

Stream Name	Species	Life Stage	Total Number of Individuals	Comments	Source
Anderson Creek	Chinook Salmon	Juvenile	2		Habitat Wizard
Anderson Creek	Chum Salmon	Unknown	1		FISS
Anderson Creek	Coho Salmon	Juvenile	2		Habitat Wizard
Anderson Creek	Coho Salmon	Unknown	1	Observed upstream of barrier (falls)	Habitat Wizard
Anderson Creek	Coho Salmon	Unknown	1	Spawning location	Habitat Wizard
Anderson Creek	Coho Salmon	Unknown	3	Spawning location	FISS
Anderson Creek	Cutthroat Trout	Unknown	1	Observed upstream of barrier (falls)	Habitat Wizard
Anderson Creek	Cutthroat Trout	Unknown	1	Spawning locations	FISS
Anderson Creek	Dolly Varden	Unknown	2	Observed upstream of barrier (falls)	Habitat Wizard
Anderson Creek	Dolly Varden	Unknown	1		FISS
Anderson Creek	Lamprey (General)	Unknown	4	Observed upstream of barrier (falls)	Habitat Wizard
Anderson Creek	Lamprey (General)	Unknown	1		FISS
Anderson Creek	Pink Salmon	Adult	2	Major spawning location	Habitat Wizard
Anderson Creek	Pink Salmon	Unknown	1	Major spawning location	FISS
Anderson Creek	Sculpin (General)	Juvenile	1		Habitat Wizard
Anderson Creek	Sculpin (General)	Unknown	2		Habitat Wizard
Anderson Creek	Sockeye Salmon	Juvenile	1		Habitat Wizard
Anderson Creek	Staghorn Sculpin	Unknown	2	Observed upstream of barrier (falls)	Habitat Wizard
Anderson Creek	Staghorn Sculpin	Unknown	1		FISS
Anderson Creek	Starry Flounder	Unknown	2	Observed upstream of barrier (falls)	Habitat Wizard

Stream Name	Species	Life Stage	Total Number of Individuals	Comments	Source
Anderson Creek	Starry Flounder	Unknown	1		FISS
Anderson Creek	Threespine Stickleback	Unknown	1		FISS
Anderson Creek	Threespine Stickleback	Unknown	2	Observed upstream of barrier (falls)	Habitat Wizard
Anderson Creek	Unidentified species	Unknown	1		Habitat Wizard
Beaver Creek	Coho Salmon	Juvenile	4	Actively rearing	Habitat Wizard
Beaver Creek	Coho Salmon	Unknown	1	Spawning location	Habitat Wizard
Beaver Creek	Cutthroat Trout	Juvenile	2	Actively rearing	Habitat Wizard
Beaver Creek	Dolly Varden	Juvenile	3	Actively rearing	Habitat Wizard
Moore Creek	Coastrange Sculpin	Juvenile	3	Actively rearing	Habitat Wizard
Moore Creek	Coho Salmon	Juvenile	4	Actively rearing	Habitat Wizard
Moore Creek	Coho Salmon	Unknown	3	Spawning location	FISS
Moore Creek	Cutthroat Trout	Juvenile	1	Actively rearing	Habitat Wizard
Moore Creek	Pink Salmon	Unknown	1	Spawning location	Habitat Wizard
Moore Creek	Pink Salmon	Unknown	1	Spawning location	FISS
Moore Creek	Prickly Sculpin	Juvenile	2	Actively rearing	Habitat Wizard
Moore Creek	Prickly Sculpin	Adult	1	Actively rearing	Habitat Wizard
Moore Creek	Rainbow Trout	Juvenile	4	Actively rearing	Habitat Wizard
Moore Creek	Threespine Stickleback	Juvenile	1	Actively rearing	Habitat Wizard
Cecil Creek	Chinook Salmon	Unknown	1	Major spawning location	FISS
Cecil Creek	Chum Salmon	Unknown	1	Spawning location	Habitat Wizard
Cecil Creek	Chum Salmon	Unknown	1	Spawning location	FISS
Cecil Creek	Coastrange Sculpin	Unknown	1		FISS
Cecil Creek	Coho Salmon	Unknown	5	Spawning location	Habitat Wizard
Cecil Creek	Coho Salmon	Unknown	3	Spawning location	FISS
Cecil Creek	Cutthroat Trout	Unknown	3		FISS
Cecil Creek	Dolly Varden	Unknown	3		FISS
Cecil Creek	Lamprey (General)	Unknown	1		FISS
Cecil Creek	Pink Salmon	Unknown	1	Spawning location	Habitat Wizard

Stream Name	Species	Life Stage	Total Number of Individuals	Comments	Source
Cecil Creek	Pink Salmon	Unknown	1	Spawning location	FISS
Cecil Creek	Rainbow Trout	Unknown	3		FISS
Cecil Creek	Steelhead	Unknown	1	Major spawning location	Habitat Wizard
Cecil Creek	Steelhead	Unknown	3	Major spawning location	FISS
Kitimat River	Chinook Salmon	Parr	3		Habitat Wizard
Kitimat River	Chinook Salmon	Unknown	3		Habitat Wizard
Kitimat River	Chum Salmon	Fry	2		Habitat Wizard
Kitimat River	Chum Salmon	Unknown	4		Habitat Wizard
Kitimat River	Coastrange Sculpin	Adult	1		Habitat Wizard
Kitimat River	Coastrange Sculpin	Unknown	2		Habitat Wizard
Kitimat River	Coho Salmon	Parr	2		Habitat Wizard
Kitimat River	Coho Salmon	Unknown	4		Habitat Wizard
Kitimat River	Cutthroat Trout	Smolt	27		Habitat Wizard
Kitimat River	Cutthroat Trout	Adult	3		Habitat Wizard
Kitimat River	Cutthroat Trout	Unknown	6		Habitat Wizard
Kitimat River	Dolly Varden	Adult	15		Habitat Wizard
Kitimat River	Dolly Varden	Unknown	4		Habitat Wizard
Kitimat River	Eulachon	Adult	26		Habitat Wizard
Kitimat River	Eulachon	Unknown	4		Habitat Wizard
Kitimat River	Kokanee	Unknown	2		Habitat Wizard
Kitimat River	Lamprey (General)	Adult	2		Habitat Wizard
Kitimat River	Lamprey (General)	Unknown	4		Habitat Wizard
Kitimat River	Pink Salmon	Unknown	2		Habitat Wizard
Kitimat River	Prickly Sculpin	Juvenile	3		Habitat Wizard
Kitimat River	Prickly Sculpin	Unknown	2		Habitat Wizard
Kitimat River	Rainbow Trout	Parr	2		Habitat Wizard
Kitimat River	Rainbow Trout	Juvenile	1		Habitat Wizard
Kitimat River	Rainbow Trout	Unknown	3		Habitat Wizard

Stream Name	Species	Life Stage	Total Number of Individuals	Comments	Source
Kitimat River	Sculpin (General)	Adult	1		Habitat Wizard
Kitimat River	Sculpin (General)	Unknown	2		Habitat Wizard
Kitimat River	Sockeye Salmon	Unknown	3		Habitat Wizard
Kitimat River	Staghorn Sculpin	Unknown	2		Habitat Wizard
Kitimat River	Starry Flounder	Unknown	1		Habitat Wizard
Kitimat River	Starry Flounder	Juvenile	2		Habitat Wizard
Kitimat River	Steelhead	Fry	1	Fall fry	Habitat Wizard
Kitimat River	Steelhead	Smolt	47		Habitat Wizard
Kitimat River	Steelhead	Adult	2		Habitat Wizard
Kitimat River	Steelhead	Unknown	35		Habitat Wizard
Kitimat River	Stickleback (General)	Unknown	2		Habitat Wizard
Kitimat River	Threespine Stickleback	Adult	1		Habitat Wizard
Kitimat River	Threespine Stickleback	Unknown	3		Habitat Wizard
Kitimat River	Unidentified species	Unknown	2		Habitat Wizard

APPENDIX C

Freshwater Fisheries Data



Table C-1 – Freshwater Wetted Areas Summary

Beaver Creek				Anderson Creek			
Unit	Length (m)	Width (m)	Area (m ²)	Unit	Length (m)	Width (m)	Area (m ²)
May 2012							
RN	111	14	1560	RN	124	13	1624
RF	26	10	258	RF	25	14	350
P	45	13	590	RN	26	12	312
RF	9	12	111	P	4	3	13
RN	46	12	557	RF	49	13	641
RF	6	10	62	RN	123	11	1351
RN	73	15	1099	P	5	4	22
P	19	15	278	P	9	9	81
P	41	11	454	RN	40	12	484
RN	87	8	693	RF	18	15	269
RF	43	8	347	RN	36	11	395
P	22	9	195	P	8	9	73
RN	185	10	1846	RN	59	13	769
P	23	25	567	RN	67	13	874
RF	15	13	201	RF	8	3	24
RN	76	7	534	RN	40	8	323
RN	46	7	325	RF	22	5	112
P	22	5	108	RN	96	13	1247
RF	18	10	175	P	5	7	38
RN	19	10	186	RF	54	14	753
RN	249	9	2237	P	9	5	45
RF	13	8	107	RN	204	12	2453
RN	438	6	2630	RN	42	4	169
P	41	15	619	RN	7	6	43
RN	41	15	619	P	5	6	32
RN	131	15	1965	RN	50	8	402
RF	8	5	41	P	5	8	43
RN	46	5	232	RF	9	8	72
-	-	-	-	RN	61	9	549
-	-	-	-	RN	18	6	108
-	-	-	-	RF	8	2	16

Beaver Creek				Anderson Creek			
Unit	Length (m)	Width (m)	Area (m ²)	Unit	Length (m)	Width (m)	Area (m ²)
-	-	-	-	P	12	6	70
-	-	-	-	RF	16	10	161
-	-	-	-	RN	58	12	699
-	-	-	-	RN	36	11	395
-	-	-	-	RF	36	5	179
-	-	-	-	RN	76	15	1143
-	-	-	-	RF	60	8	481
-	-	-	-	P	8	7	56
-	-	-	-	RN	59	17	1006
-	-	-	-	RF	58	18	1049
Total Area			18,596	Total Area			18,926

June 2012

RN	135	15	2025	RN	175	14	2503
RF	15	15	221	RN	224	12	2693
P	40	13	526	P	7	5	33
RN	58	13	750	P	8	10	83
RF	12	12	147	RN	38	1	51
RN	81	15	1215	RF	25	1	25
P	18	15	276	P	21	10	207
P	49	12	589	RN	46	13	592
RN	130	8	1041	P	5	6	30
P	29	8	236	RN	157	15	2360
RN	220	11	2416	RF	47	12	567
P	27	25	675	RN	33	15	497
RF	13	12	162	P	5	7	35
RN	25	8	196	RN	25	15	373
P	12	5	61	RF	31	5	153
RN	61	10	614	RN	25	15	373
P	26	11	283	P	8	5	41
RN	175	9	1579	RN	51	15	770
RF	13	8	108	RF	17	4	66
RN	492	6	2953	RN	39	4	156
P	75	15	1123	RN	50	15	745
RN	156	6	935	P	5	4	20
RF	6	5	31	P	11	3	32
RN	31	5	153	RF	7	4	27
-	-	-	-	RN	166	7	1160
-	-	-	-	P	5	6	30
-	-	-	-	RF	5	8	40
-	-	-	-	RN	16	7	110
-	-	-	-	RF	4	8	33
-	-	-	-	RN	28	7	197

Beaver Creek				Anderson Creek			
Unit	Length (m)	Width (m)	Area (m ²)	Unit	Length (m)	Width (m)	Area (m ²)
-	-	-	-	P	9	8	73
-	-	-	-	RN	54	20	1077
-	-	-	-	RF	21	15	311
-	-	-	-	RF	41	15	609
-	-	-	-	RN	68	15	1019
-	-	-	-	RF	52	24	1252
-	-	-	-	P	7	7	52
-	-	-	-	RN	52	18	939
-	-	-	-	RN	49	8	391
-	-	-	-	RF	25	10	248
Total Area			18,315	Total Area			19,973

September 2012

RN	111	13	1442	RF	25	18	454
RF	15	10	154	RN	96	15	1444
P	34	12	407	RF	16	8	127
RF	7	12	86	RN	61	10	607
RN	41	12	493	RF	13	8	105
RF	8	10	82	P	16	14	222
RN	68	15	1017	RN	20	14	275
P	15	15	231	RF	27	19	515
P	41	10	411	P	9	8	75
RN	62	7	431	RF	28	12	336
RF	47	7	331	RN	37	5	187
P	25	8	197	RF	6	7	39
RN	65	11	712	P	6	4	22
RN	68	12	813	P	11	6	67
RN	51	8	411	RN	13	7	92
P	23	25	565	RF	17	8	135
RF	13	12	160	P	23	9	210
RN	13	12	160	RN	31	10	308
RN	22	6	129	RF	17	3	50
RF	5	4	21	P	28	4	112
RN	8	4	33	RN	37	4	150
RF	32	9	287	RF	51	1	51
RN	32	9	287	RN	34	7	236
P	14	8	115	RN	82	15	1234
RN	15	3	46	RN	24	17	413
RF	15	10	154	RF	17	14	236
RN	21	10	205	P	28	9	252
RN	81	9	730	RF	33	7	229
RN	49	9	444	P	19	9	168
RN	66	8	526	RN	8	8	67

Beaver Creek				Anderson Creek			
Unit	Length (m)	Width (m)	Area (m ²)	Unit	Length (m)	Width (m)	Area (m ²)
RN	31	7	216	RF	14	6	84
RF	10	7	72	P	22	7	157
RF	31	3	92	RF	20	9	177
RN	46	3	139	RN	29	11	319
RN	154	5	770	RF	8	11	93
RN	62	5	308	P	8	9	76
RF	21	8	164	RF	5	8	37
RN	18	8	148	RN	66	12	796
RN	41	6	246	RF	42	10	421
P	72	15	1078	RF	19	8	150
P	15	14	216	RN	123	15	1850
RN	36	14	503	RF	28	20	561
RN	123	6	739	RN	39	13	510
RN	130	5	652	RF	63	13	814
RF	15	5	77	RN	62	17	1049
P	27	4	107	P	103	15	1542
September 2012 Total Area			16,607	September 2012 Total Area			17,054

January 2013

C	0.5	35	17.5	RF	23	14	328
RF	28	21	588	RN	121	18	2123
RN	22	11	242	RF	5	16	82
P	54	20	1080	P	41	12	489
RN	21	16	336	RN	36	17	606
P	50	20	1000	RF	36	24	856
RN	19	15	285	P	20	13	265
P	57	20	1140	RN	41	13	530
RN	7	7	49	RF	15	14	214
P	21	13	273	P	12	10	122
RF	5	15	75	P	9	12	110
-	-	-	-	RF	4	6	24
-	-	-	-	RN	6	10	61
-	-	-	-	P	8	9	73
-	-	-	-	RN	34	9	286
-	-	-	-	RF	22	8	168
-	-	-	-	RN	9	4	37
-	-	-	-	P	12	6	73
-	-	-	-	RN	10	5	51
-	-	-	-	RF	22	9	202
-	-	-	-	P	16	6	90
-	-	-	-	RF	41	9	367
-	-	-	-	RN	46	18	826
-	-	-	-	P	31	7	214

Beaver Creek				Anderson Creek			
Unit	Length (m)	Width (m)	Area (m ²)	Unit	Length (m)	Width (m)	Area (m ²)
-	-	-	-	RF	8	7	57
-	-	-	-	RF	22	10	213
-	-	-	-	P	20	6	122
-	-	-	-	P	11	8	84
-	-	-	-	RN	36	10	366
-	-	-	-	RF	17	27	468
-	-	-	-	RN	30	6	177
-	-	-	-	P	15	8	122
-	-	-	-	RN	7	9	64
-	-	-	-	P	12	8	92
-	-	-	-	RN	16	11	179
-	-	-	-	P	13	10	126
-	-	-	-	RN	12	17	208
-	-	-	-	RF	5	14	71
-	-	-	-	RN	23	5	117
-	-	-	-	RF	28	8	220
-	-	-	-	RN	102	12	1223
-	-	-	-	RF	19	19	368
-	-	-	-	P	24	17	416
-	-	-	-	P	24	15	367
-	-	-	-	RF	25	9	229
-	-	-	-	RN	39	7	252
-	-	-	-	P	19	9	174
-	-	-	-	RF	3	10	31
-	-	-	-	RN	10	8	82
-	-	-	-	P	25	5	115
-	-	-	-	P	21	6	118
-	-	-	-	RF	22	7	146
-	-	-	-	RF	39	6	232
-	-	-	-	P	10	7	66
-	-	-	-	RN	110	7	771
-	-	-	-	P	8	7	57
-	-	-	-	RF	33	7	228
-	-	-	-	RN	64	13	835
-	-	-	-	P	62	12	715
-	-	-	-	RF	16	10	158
January 2013 Total Area			5,086	January 2013 Total Area			17,138

NOTE: RF = riffle habitat, RN = run habitat, P = pool habitat.



Table C-2 – Freshwater Fish Catch and Effort Summary

Watercourse	Site	UTM	Date	Total Effort	Total Catch
DN					
Kitimat R. West	KMT-1	9U 521095E 5986210N	16-Mar-13	-	10
Open-site EF					
Anderson Creek	AEF-1-1	9U 520150E 5985831N	23-May-12	811 s	4
Anderson Creek	AEF-1-2	9U 520266E 5985523N	25-Jun-12	550 s	15
Anderson Cr. N.	ANCEF-1	9U 520143E 5986126N	24-May-12	250 s	3
			25-Jun-12	585 s	1
Anderson Cr. E.	BEF-2-2	9U 520340E 5986013N	24-May-12	502 s	18
			25-Jun-12	448 s	-
Beaver Creek	BEF-2-1	9U 520238E 5986271N	24-May-12	450 s	5
			25-Jun-12	335 s	-
Upper Wetland	BEF-3-1	9U 520044E 5987016N	20-May-13	107 s	5
	BEF-3-2	9U 520019E 5986948N	20-May-13	345 s	2
Cecil Creek	CEF-2A	9U 523072E 6015197N	11-Sep-12	117 s	20
Total				4500 s	73
Closed-site EF					
Anderson Creek	AEF-1-1	9U 520150E 5985831N	9-Sep-12	436 s	24
			9-Sep-12	1205 s	9
Anderson Creek	AEF-1-2	9U 520266E 5985523N	24-Jun-12	303 s	-
Beaver Creek	BEF-1-1	9U 520188E 5986496N	22-May-12	1158 s	16
	BEF-1-2	9U 520196E 5986482N	25-Jun-12	1567 s	36
Cecil Creek	CEF-1-1	9U 523063E 6015416N	26-Jun-12	793 s	29
	CEF-1-2	9U 523013E 6014969N	11-Sep-12	582 s	33
Moore Creek	MEF-1-1	9U 520439E 5984825N	10-Sep-12	518 s	10
	MEF-1-2		10-Sep-12	1087 s	66
Total				7649 s	223
GT					
Anderson Cr. N.	ANCMT-1	9U 520122E 5986102N	28-Jan-13	88 h	15
	ANCMT-2	9U 520149E 5986119N	28-Jan-13	108 h	16

Watercourse	Site	UTM	Date	Total Effort	Total Catch
Anderson Cr. S.	ANCMT-3	9U 520117E 5985922N	25-May-12	191 h	38
	ASCMT-1	9U 520157E 5985783N	26-Jan-13	79 h	11
	ASCMT-2	9U 520131E 5985681N	15-Mar-13	27 h	8
		9U 520142E 5985671N	15-Mar-13	26 h	14
		9U 520199E 5985597N	15-Mar-13	27 h	7
	ASCMT-3	9U 520183E 5985679N	15-Mar-13	26 h	15
		9U 520212E 5985538N	15-Mar-13	26 h	18
		9U 520218E 5985502N	15-Mar-13	26 h	1
		9U 520221E 5985464N	15-Mar-13	27 h	5
		9U 520221E 5985486N	15-Mar-13	27 h	26
		9U 520236E 5985393N	15-Mar-13	27 h	9
Anderson Creek	AMT-2-1	9U 520237E 5985683N	25-Jan-13	18 h	2
	AMT-2-2	9U 520251E 5985682N	25-Jan-13	36 h	5
	AMT-2-3	9U 520268E 5985648N	25-Jan-13	54 h	12
	AMT-2-4	9U 520256E 5985631N	25-Jan-13	36 h	6
	AMT-2-5	9U 520275E 5985562N	25-Jan-13	36 h	6
		9U 520281E 5985542N	25-Jan-13	36 h	2
	AMT-2-6	9U 520287E 5985516N	25-Jan-13	18 h	1
		9U 520288E 5985514N	25-Jan-13	18 h	4
	AMT-2-7	9U 520255E 5985534N	25-Jan-13	36 h	6
	AMT-2-8	9U 520263E 5985504N	25-Jan-13	18 h	-
		9U 520265E 5985503N	25-Jan-13	36 h	1
	AMT-3	9U 520256E 5985496N	10-Sep-12	5 h	2
		9U 520273E 5985539N	10-Sep-12	5 h	8
	AMT-4	9U 520256E 5985496N	10-Sep-12	5 h	21
		9U 520273E 5985539N	10-Sep-12	5 h	8
	AMT-5	9U 520290E 5985474N	10-Sep-12	5 h	18
	AMT-6	9U 520346E 5985457N	10-Sep-12	5 h	28
	AMT-7-0	9U 520384E 5985401N	24-May-12	186 h	7
	AMT-8	9U 520095E 5985842N	20-Jun-12	425 h	19
	AMT-8-0		20-May-12	96 h	2
AMT-8-1	9U 519983E 5985805N	15-Mar-13	28 h	1	
AMT-8-4	9U 520110E 5985841N	15-Mar-13	28 h	1	
AMT-8-5	9U 520133E 5985818N	15-Mar-13	28 h	1	
MMT-0	9U 520694E 5984922N	24-Jun-12	235 h	120	
MMT-0-1		23-May-12	94 h	11	

Watercourse	Site	UTM	Date	Total Effort	Total Catch
	MMT-0-2		23-May-12	24 h	-
	MT-0-0	9U 520679E 5985128N	20-May-12	89 h	53
Beaver Creek	BMT-0-1	9U 520194E 5986527N	20-May-12	100 h	11
	BMT-1	9U 520215E 5986484N	22-Jun-12	430 h	104
	BMT-1-1	9U 520189E 5986494N	8-Sep-12	5 h	51
	BMT-1-2	9U 520215E 5986484N	8-Sep-12	5 h	107
	BMT-1-3	9U 520231E 5986467N	8-Sep-12	16 h	119
	BMT-1-4	9U 520215E 5986483N	29-Jan-13	342 h	166
Cecil Creek	CMT-1	9U 523063E 6015416N	26-Jun-12	203 h	29
Dyke Area	DMT-1	9U 520957E 5985441N	16-Mar-13	60 h	54
	DMT-2	9U 521607E 5985131N	16-Mar-13	52 h	1
	DMT-3	9U 521646E 5985231N	16-Mar-13	21 h	-
	DMT-4	9U 521648E 5985422N	16-Mar-13	22 h	-
	DMT-E	9U 520550E 5986139N	17-May-13	73 h	-
	DMT-W-1	9U 520495E 5986078N	17-May-13	48 h	-
	DMT-W-2	9U 520485E 5986076N	17-May-13	48 h	18
Eurocan Slough	EMT-1-1	9U 519942E 5987406N	13-Mar-13	22 h	2
	EMT-1-10	9U 520414E 5987413N	13-Mar-13	22 h	9
	EMT-1-2	9U 519934E 5987410N	13-Mar-13	22 h	4
	EMT-1-3	9U 519825E 5987611N	13-Mar-13	22 h	1
	EMT-1-4	9U 520043E 5987369N	13-Mar-13	22 h	5
	EMT-1-5	9U 520119E 5987367N	13-Mar-13	22 h	12
	EMT-1-6	9U 520362E 5987391N	13-Mar-13	22 h	5
	EMT-1-7	9U 520784E 5987436N	13-Mar-13	22 h	1
	EMT-1-8	9U 520546E 5987450N	13-Mar-13	22 h	1
	EMT-1-9	9U 520414E 5987413N	13-Mar-13	22 h	13
Kitimat R. West	KMT-1	9U 521052E 5986753N	16-Mar-13	21 h	-
	KMT-10	9U 521768E 5985831N	16-Mar-13	22 h	2
	KMT-11	9U 521653E 5985776N	16-Mar-13	21 h	18
	KMT-2	9U 521115E 5986546N	16-Mar-13	21 h	2
	KMT-3	9U 521139E 5986350N	16-Mar-13	21 h	-
	KMT-4	9U 521107E 5986077N	16-Mar-13	21 h	6
	KMT-6	9U 521513E 5985896N	16-Mar-13	21 h	-
	KMT-8	9U 521647E 5985822N	16-Mar-13	22 h	1
	KMT-9	9U 521626E 5985821N	16-Mar-13	22 h	1
Lower Wetland	BMT-7-1	9U 520002E 5986642N	15-Mar-13	25 h	16

Watercourse	Site	UTM	Date	Total Effort	Total Catch
	BMT-7-2	9U 520037E 5986614N	15-Mar-13	24 h	14
		9U 520045E 5986614N	15-Mar-13	24 h	21
	BMT-7-3	9U 520068E 5986611N	15-Mar-13	25 h	28
	BMT-7-4	9U 520088E 5986612N	15-Mar-13	26 h	3
	BMT-7-5	9U 520143E 5986588N	15-Mar-13	26 h	18
	CMP-1	9U 519988E 5986465N	19-May-13	25 h	-
		9U 520000E 5986459N	19-May-13	25 h	-
		9U 520000E 5986467N	19-May-13	25 h	-
		9U 520004E 5986479N	19-May-13	25 h	-
		9U 520005E 5986450N	19-May-13	25 h	-
		9U 520021E 5986810N	29-Jan-13	152 h	-
		9U 520045E 5986614N	19-May-13	25 h	-
	CMP-2	9U 519388E 5986887N	30-Jan-13	196 h	3
		9U 519862E 5986641N	17-May-13	23 h	-
		9U 519866E 5986661N	17-May-13	23 h	-
		9U 519883E 5986627N	17-May-13	23 h	-
		9U 519896E 5986629N	17-May-13	21 h	3
		9U 519906E 5986632N	17-May-13	20 h	6
		9U 519939E 5986607N	17-May-13	20 h	6
	WHR-1	9U 520077E 5986278N	15-Mar-13	48 h	-
	WHR-2	9U 520049E 5986233N	15-Mar-13	47 h	-
	WHR-3	9U 520033E 5986201N	15-Mar-13	47 h	-
	WHR-4	9U 519994E 5986976N	15-Mar-13	45 h	-
	WHR-5	9U 520003E 5986088N	15-Mar-13	45 h	-
WHR-6	9U 519984E 5986050N	15-Mar-13	44 h	-	
Moore Creek	MMT-1-1	9U 520273E 5984859N	10-Sep-12	150 h	71
	MMT-1-2	9U 520293E 5984852N	10-Sep-12	4 h	63
	MMT-1-3	9U 520212E 5984850N	10-Sep-12	4 h	8
	MMT-3-1	9U 520428E 5984827N	26-Jan-13	54 h	8
	MMT-3-10	9U 520166E 5984786N	26-Jan-13	18 h	1
	MMT-3-11	9U 520151E 5984792N	26-Jan-13	18 h	4
	MMT-3-2	9U 520413E 5984883N	26-Jan-13	18 h	2
	MMT-3-3	9U 520352E 5984856N	26-Jan-13	18 h	1
	MMT-3-4	9U 520269E 5984872N	26-Jan-13	18 h	1
		9U 520283E 5984869N	26-Jan-13	18 h	1
		9U 520290E 5984863N	26-Jan-13	18 h	4

Watercourse	Site	UTM	Date	Total Effort	Total Catch
		9U 520295E 5984868N	26-Jan-13	18 h	1
		9U 520304E 5984858N	26-Jan-13	18 h	5
	MMT-3-5	9U 520221E 5984865N	26-Jan-13	18 h	-
	MMT-3-6	9U 520180E 5984840N	26-Jan-13	18 h	-
	MMT-3-7	9U 520162E 5984831N	26-Jan-13	18 h	10
		9U 520166E 5984825N	26-Jan-13	18 h	2
		9U 520166E 5984828N	26-Jan-13	36 h	2
	MMT-3-8	9U 520180E 5984821N	26-Jan-13	18 h	1
	MMT-3-9	9U 520167E 5984799N	26-Jan-13	18 h	1
Upper Wetland	BMT-5-1	9U 519849E 5987373N	13-Mar-13	22 h	19
	BMT-5-10	9U 519786E 5987197N	13-Mar-13	22 h	-
	BMT-5-2	9U 519855E 5987374N	13-Mar-13	22 h	2
	BMT-5-3	9U 519839E 5987360N	13-Mar-13	21 h	7
	BMT-5-4	9U 519815E 5987365N	13-Mar-13	22 h	-
	BMT-5-5	9U 519808E 5987377N	13-Mar-13	22 h	-
	BMT-5-6	9U 519779E 5987386N	13-Mar-13	23 h	-
	BMT-5-7	9U 519764E 5987332N	13-Mar-13	22 h	-
	BMT-5-8	9U 519730E 5987349N	13-Mar-13	22 h	-
	BMT-5-9	9U 519839E 5987360N	13-Mar-13	23 h	5
	BMT-6-10	9U 519731E 5987046N	14-Mar-13	23 h	-
	BMT-6-2	9U 519537E 5987050N	13-Mar-13	21 h	40
	BMT-6-3	9U 519554E 5987049N	13-Mar-13	22 h	38
		9U 519598E 5987072N	13-Mar-13	22 h	9
	BMT-6-4	9U 519673E 5987056N	13-Mar-13	22 h	1
		9U 519622E 5987054N	13-Mar-13	22 h	45
	BMT-6-5	9U 519640E 5987045N	13-Mar-13	22 h	45
	BMT-6-6	9U 519667E 5987046N	13-Mar-13	22 h	2
	BMT-6-7	9U 519673E 5987056N	13-Mar-13	22 h	12
	BMT-6-8	9U 519688E 5987046N	13-Mar-13	22 h	20
	BMT-6-9	9U 519957E 5986855N	13-Mar-13	44 h	32
	BMT-8-1	9U 519902E 5986923N	13-Mar-13	184 h	25
	BMT-8-2	9U 520041E 5986958N	14-Mar-13	36 h	16
	BMT-8-3		14-Mar-13	36 h	21
	BMT-8-4	9U 519638E 5987360N	31-Jan-13	117 h	12
	Total				6577 h

MT

Anderson Cr. N.	ANCMT-1	9U 520122E 5986102N	10-Sep-12	96 h	33	
			28-Jan-13	44 h	3	
	ANCMT-2	9U 520149E 5986118N	10-Sep-12	98 h	39	
			9U 520149E 5986119N	28-Jan-13	43 h	16
Anderson Creek	AMT-1-1	9U 520220E 5985805N	9-Sep-12	6 h	58	
			9U 520229E 5985805N	10-Jan-13	9 h	1
	AMT-1-2	9U 520212E 5985793N	9-Sep-12	7 h	3	
			10-Jan-13	12 h	-	
Beaver Creek	BMT-1-4	9U 520229E 5986409N	9-Sep-12	126 h	55	
	BMT-1-5	9U 520247E 5986329N	9-Sep-12	144 h	23	
	BMT-2	9U 520561E 5985793N	10-Sep-12	6 h	10	
	BMT-3	9U 520586E 5985804N	10-Sep-12	6 h	29	
Dyke Area	DMT-1	9U 520957E 5985441N	16-Mar-13	20 h	3	
	DMT-2	9U 521607E 5985131N	16-Mar-13	17 h	1	
	DMT-3	9U 521646E 5985231N	16-Mar-13	21 h	-	
Kitimat R. West	KMT-10	9U 521768E 5985831N	16-Mar-13	44 h	-	
	KMT-5	9U 521473E 5985964N	16-Mar-13	21 h	-	
	KMT-6	9U 521513E 5985896N	16-Mar-13	21 h	1	
	KMT-7	9U 521560E 5985845N	16-Mar-13	22 h	1	
	KMT-8	9U 521647E 5985822N	16-Mar-13	22 h	-	
	KMT-9	9U 521626E 5985821N	16-Mar-13	44 h	-	
Moore Creek	MMT-2-1	9U 520427E 5984841N	10-Sep-12	4 h	1	
	MMT-2-2	9U 520413E 5984865N	10-Sep-12	10 h	3	
Upper Beaver Cr.	BMT-4	9U 519126E 5987320N	13-Dec-12	243 h	36	
			11-Jan-13	324 h	12	
	BMT-4-1	9U 519124E 5987330N	26-Jan-13	27 h	-	
			9U 519127E 5987326N	26-Jan-13	27 h	-
			9U 519131E 5987323N	26-Jan-13	27 h	1
			9U 519137E 5987318N	26-Jan-13	27 h	-
			9U 519140E 5987311N	26-Jan-13	27 h	2
	BMT-4-2	9U 519146E 5987307N	26-Jan-13	27 h	2	
			9U 519150E 5987306N	26-Jan-13	27 h	-
			9U 519156E 5986306N	26-Jan-13	27 h	2
			9U 519165E 5987306N	26-Jan-13	27 h	1
9U 519167E 5987306N			26-Jan-13	27 h	-	
BMT-4-3	9U 519096E 5987356N	26-Jan-13	27 h	-		

Watercourse	Site	UTM	Date	Total Effort	Total Catch
		9U 519100E 5987344N	26-Jan-13	27 h	1
		9U 519101E 5987349N	26-Jan-13	27 h	1
		9U 519105E 5987358N	26-Jan-13	27 h	-
		9U 519115E 5987339N	26-Jan-13	27 h	1
Upper Wetland	BMT-6-1	9U 519523E 5987088N	13-Mar-13	64 h	3
Total				1879 h	342

NOTE: DN = dip netting, EF = electrofishing, GT = Gee trapping, MT = mesh trapping

APPENDIX D

Estuarine Fisheries Data



1308 – 1030 W. Georgia Street
Vancouver, BC V6E 2Y3

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Table D-1 – Estuary Water Quality Summary

Site	Temperature (°C)		pH		DO (mg/L)		Salinity (‰)		ORP (mV)		Conductivity (µS/cm)	
	mean	σ	mean	σ	mean	σ	mean	σ	mean	σ	mean	σ
Water Quality Summary by Site												
EA-1	8.6	4.24	7.4	0.51	8.79	2.14	16.64	9.51	45.93	126.55	12738	10202
EA-2	7.7	5.15	7.4	0.53	9.79	1.97	11.83	10.70	84.25	126.06	8535	8683
EA-3	6.8	4.22	7.3	0.42	9.37	2.51	8.71	9.38	124.93	89.56	11623	16888
EC-1	7.2	3.52	7.6	0.92	9.21	1.44	13.61	10.64	65.68	77.84	13242	9401
Site EA-1												
Jan	-0.4	-	7.0	-	8.20	-	26.50	-	-40.60	-	22485	-
Feb	3.2	-	7.2	-	ND	-	ND	-	ND	-		
Mar	6.1	0.21	7.9	0.10	10.41	0.15	26.82	2.07	176.80	24.61	27065	2016
Apr	9.9	2.10	7.7	0.82	9.91	1.82	18.58	0.01	116.80	58.48	14774	11590
May	11.4	1.28	7.3	0.37	8.83	3.14	8.00	8.77	18.28	162.14	6783	7495
Jun	12.7	3.82	7.6	0.36	8.74	0.74	2.52	-	0.30	85.28	2853	1372
Sep	14.3	-	7.7	-	ND	-	ND	-	ND	-	ND	-
Oct	7.8	-	6.8	-	4.93	-	5.94	-	ND	-	7055	-

Site	Temperature (°C)		pH		DO (mg/L)		Salinity (‰)		ORP (mV)		Conductivity (µS/cm)	
Nov	4.5	-	7.0	-	7.20	-	23.44	-	ND	-	ND	-
Dec	4.6	-	6.8	-	8.21	-	17.90	-	-140.00	-	17500	-

Site EA-2

Jan	-1.6	-	7.5	-	11.50	-	29.58	-	4.90	-	23808	-
Feb	3.1	-	7.5	-	ND	-	ND	-	ND	-	ND	-
Mar	4.9	1.34	7.7	0.24	9.80	1.79	17.80	11.78	220.40	27.01	18025	11593
Apr	8.0	2.69	7.9	0.42	9.90	0.51	9.11	0.52	142.10	16.55	10551	1221
May	11.9	4.54	7.4	0.32	8.77	2.17	1.00	1.26	-0.63	160.36	2568	815
	mean	σ	mean	σ	mean		mean	σ	mean	σ	620	560
Jun	10.4	2.97	7.6	1.01	8.89	1.12	0.14	-	129.50	100.55	ND	-
Sep	14.1	-	6.9	-	ND	-	ND	-	ND	-	ND	-
Oct	ND	-	ND	-	ND	-	ND	-	ND	-	9950	-
Nov	4.5	-	6.9	-	ND	-	22.50	-	ND	-	23808	-
Dec	2.0	-	6.4	-	13.70	-	10.22	-	24.60	-	ND	-

Site EA-3

Jan	0.5	-	7.6	-	ND	-	22.80	-	ND	-	27941	-
Feb	2.9	-	6.8	-	ND	-	ND	-	ND	-	ND	-
Mar	4.6	1.84	7.3	0.15	9.70	2.45	17.15	15.49	198.40	65.48	44484	22647
Apr	7.3	1.05	7.5	0.15	8.39	1.04	9.58	0.55	48.90	120.38	10145	985
May	10.4	2.33	7.3	0.48	8.06	1.24	1.36	0.06	148.43	63.05	2405	1409
Jun	9.7	2.47	7.8	0.11	9.19	0.71	0.82	-	139.50	102.53	1294	140

Site	Temperature (°C)		pH		DO (mg/L)		Salinity (‰)		ORP (mV)		Conductivity (µS/cm)	
Sep	13.0	-	7.4	-	ND	-	ND	-	ND	-	ND	-
Oct	6.9	-	6.7	-	10.03	-	1.16	-	ND	-	1476	-
Nov	0.0	-	7.4	-	ND	-	13.15	-	ND	-	ND	-
Dec	0.5	-	6.4	-	16.57	-	1.66	-	83.00	-	1701	-

Site EC-1

Jan	4.7	-	7.5	-	9.25	-	29.67	-	49.80	-	28584	-
Feb	3.4	-	ND		ND	-	ND	-	ND	-	ND	-
Mar	4.2	1.06	7.0	0.35	8.64	0.74	8.96	10.27	19.65	61.87	9261	10255
Apr	7.6	2.55	8.4	-	9.99	1.15	18.48	-	104.50	32.67	17796	4685
May	11.4	0.35	8.7	1.69	9.33	0.36	5.78	5.81	89.55	114.76	7424	7191
Jun	9.3	-	7.4	-	5.86	-	1.88	-	-47.00	-	3062	-
Sep	13.6	-	8.1	-	ND	-	ND	-	ND	-	ND	-
Oct	7.9	-	6.7	-	10.50	-	7.03	-	ND	-	8082	-
Nov	3.5	-	7.1	-	ND	-	25.29	-	ND	-	ND	-
Dec	4.5	-	7.2	-	10.54	-	24.32	-	160.90	-	23737	-

NOTE: σ denotes standard deviation, ND = No Data.



1308 – 1030 W. Georgia Street
Vancouver, BC V6E 2Y3

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Table D-2 – Estuary Fish Catch Summary

Species	Site EA-1			Site EA-2			Site EA-3			Site EC-1		
	Sets	Catch	CPUA	Sets	Catch	CPUA	Sets	Catch	CPUA	Sets	Catch	CPUA
Apr 2012												
CM	1	18	1.51E-02	1	0	0	1	19	1.61E-02	-	-	-
CO	1	0	0	1	0	0	1	1	8.47E-04	-	-	-
TSB	1	1	8.40E-04	1	0	0	1	1	8.47E-04	-	-	-
CLA	1	1	8.40E-04	1	0	0	1	3	2.54E-03	-	-	-
May 2012												
CH	3	45	1.50E+01	3	1	3.33E-01	3	0	0	-	-	-
CM	3	945	3.15E+02	3	5	1.67E+00	3	0	0	-	-	-
CO	3	5	1.67E+00	3	0	0	3	1	3.33E-01	-	-	-
PK	3	6	2.00E+00	3	0	0	3	0	0	-	-	-
SK	3	3	1.00E+00	3	0	0	3	0	0	-	-	-
TSB	3	2	6.67E-01	3	2	6.67E-01	3	5	1.67E+00	-	-	-
CLA	3	37	1.23E+01	3	1	3.33E-01	3	5	1.67E+00	-	-	-
SFL	3	1	3.33E-01	3	0	0	3	0	0.00E+00	-	-	-

Species	Site EA-1			Site EA-2			Site EA-3			Site EC-1		
	Sets	Catch	CPUA	Sets	Catch	CPUA	Sets	Catch	CPUA	Sets	Catch	CPUA
Jun 2012												
CLA	1	12	1.01E-02	1	0	0	1	3	2.54E-03	0	0	0
Sep 2012												
CO	1	1	8.40E-04	1	0	0	1	3	2.54E-03	1	2	8.20E-03
TSB	1	0	0	1	0	0	1	0	0	1	1	4.10E-03
CLA	1	11	9.24E-03	1	19	2.37E-01	1	2	1.69E-03	1	8	3.28E-02
Oct 2012												
CO	1	6	5.04E-03	0	-	-	1	29	2.46E-02	1	7	2.87E-02
TSB	1	0	0	0	-	-	1	2	1.69E-03	1	2	8.20E-03
CLA	1	2	1.68E-03	0	-	-	1	0	0	1	6	2.46E-02
Nov 2012												
CLA	1	0	0	1	0	0	1	0	0	1	7	2.87E-02
Dec 2012												
CO	1	6	5.04E-03	1	1	1.25E-02	1	0	0	1	0	0
TSB	1	0	0	1	15	1.87E-01	1	0	0	1	0	0
CLA	1	2	1.68E-03	1	0	0	1	0	0	1	0	0
Jan-13												
TSB	1	0	0	1	0	0	1	1	8.47E-04	1	0	0
CLA	1	0	0	1	0	0	1	0	0	1	1	4.10E-03

Species	Site EA-1			Site EA-2			Site EA-3			Site EC-1		
	Sets	Catch	CPUA	Sets	Catch	CPUA	Sets	Catch	CPUA	Sets	Catch	CPUA
Feb-13												
CM	1	7	5.88E-03	1	2	2.50E-02	1	0	0	1	0	0
TSB	1	0	0	1	174	2.17E+00	1	0	0	1	0	0
CLA	1	0	0	1	0	0	1	2	1.69E-03	1	0	0
Mar-13												
CH	2	1	4.20E-04	2	0	0	2	3	1.27E-03	2	0	0
CM	2	23	9.66E-03	2	0	0	2	7	2.97E-03	2	0	0
CO	2	1	4.20E-04	2	3	1.87E-02	2	0	0	2	0	0
PK	2	0	0	2	0	0	2	2	8.47E-04	2	0	0
SK	2	0	0	2	1	6.25E-03	2	0	0	2	0	0
TSB	2	0	0	2	34	2.12E-01	2	36	1.53E-02	2	1	4.10E-03
CLA	2	11	4.62E-03	2	1	6.25E-03	2	28	1.19E-02	2	2	8.20E-03
Apr-13												
CM	2	0	0	2	0	0	2	155	6.57E-02	2	8	3.28E-02
TSB	2	0	0	2	0	0	2	0	0	2	5	2.05E-02
CLA	2	27	1.13E-02	2	0	0	2	7	2.97E-03	2	7	2.87E-02
May-13												
CH	2	0	0	2	1	6.25E-03	2	0	0	2	23	9.43E-02

Species	Site EA-1			Site EA-2			Site EA-3			Site EC-1		
	Sets	Catch	CPUA	Sets	Catch	CPUA	Sets	Catch	CPUA	Sets	Catch	CPUA
CM	2	0	0	2	35	2.19E-01	2	31	1.31E-02	2	0	0
CO	2	0	0	2	0	0	2	1	4.24E-04	2	64	2.62E-01
CLA	2	10	4.20E-03	2	0	0	2	23	9.74E-03	2	14	5.74E-02

Jun-13

CO	1	0	0	1	0	0	1	0	0	1	3	1.23E-02
TSB	1	0	0	1	0	0	1	1	8.47E-04	1	0	0
CLA	1	0	0	1	0	0	1	17	1.44E-02	1	7	2.87E-02

NOTE: CPUA = catch per unit area (fish/m²)

APPENDIX E

Representative Habitat Photos

Appendix E Representative Habitat Photos

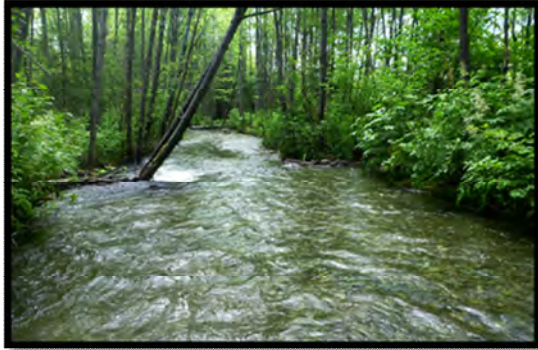


Photo E-1: Typical Habitat observed in Anderson Creek

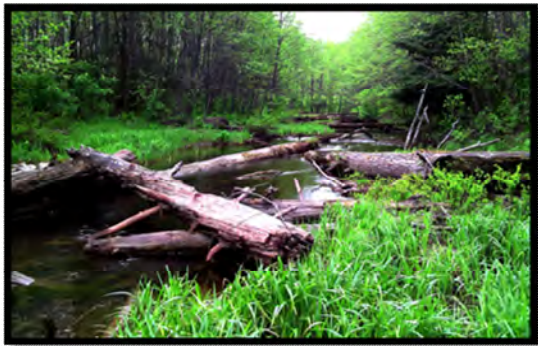


Photo E-2: Typical habitat observed in Beaver Creek



Photo E-3: Typical Habitat Observed in Moore Creek



Photo E-4: Typical habitat observed at estuary site EA-1 during high tide



Photo E-5: Typical habitat observed at estuary site EA-2 during low tide

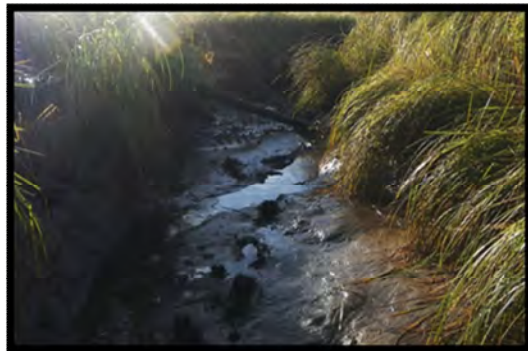


Photo E-6: Typical Habitat Observed at estuary site EA-3 during low tide

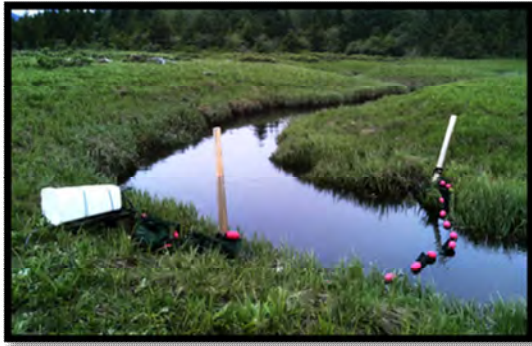


Photo E-7: Typical Habitat observed at EC-1 during high tide (left) and low tide (right)

APPENDIX F

Effects Assessment Technical Report

Project number: 6018-01/WP3667

Revision: 7

Date: August 2014

LNG CANADA PROJECT FRESHWATER AND ESTUARINE FISH & FISH HABITAT

EFFECTS ASSESSMENT TECHNICAL REPORT

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Executive Summary

This report represents an appendix to the technical data report (TDR; Triton 2014a) of the LNG Canada Freshwater and Estuarine Fish and Fish Habitat Valued Component (VC) assessment. It has considered the environmental risks posed by the LNG Canada Export Terminal Project (i.e., the Project). Risks to the VC posed by the Project are most likely to occur through the development of the liquefied natural gas (LNG) facility footprint in the form of *Serious Harm to Fish* important to commercial, recreational, and Aboriginal (CRA) fisheries. Activities leading to these effects will mostly occur during the facility construction phase and its associated onshore site preparation activities. The primary purpose of this assessment has been to quantitatively evaluate the extent of harm expected due to permanent alteration to or destruction of (PAD) freshwater and estuarine fish habitat.

Natural and anthropogenic processes have had a combined effect on fish production in freshwater and estuarine habitats affected by the Project. A previously constructed 2 km dike bisects the estuary floodplain and isolates fish in wetted habitats on either side. Upstream of the estuary, all surface flow interaction has been lost between the Lower Kitimat River to the east and Moore and Anderson creeks (i.e., *Yaksda wa'wais*) to the west. Habitat west of the dike appears to support a surplus in productivity of juvenile Coho Salmon (CO) *Oncorhynchus kisutch*, likely due to semi-annual pulses associated with freshet flows in spring and high precipitation in the fall that introduce Kitimat River CO to the system via the estuary channels. Beaver Creek is the principal tributary of Anderson Creek and appears to provide accessible CO rearing and overwintering habitat throughout its lower reaches, which include the Project footprint. Base flows during late winter (i.e., March) represent the most likely factor limiting annual production of CO. This has ecological implications on the role of both mainstem and off-channel wetted habitats in the freshwater and estuarine aquatic ecosystems affected by the Project.

An estimated total of 891,266 m² of freshwater riparian habitat is expected to be lost by the Project footprint as currently designed. This consists mostly of stream riparian habitat (837,276 m²) and a limited amount of wetland riparian habitat that holds high fish value (53,990 m²). Total estuarine riparian losses are located in an Environmentally Sensitive Area (ESA) and amount to 28,987 m². This consists mostly of riparian habitat associated with streams and tidal channels (20,494 m²) and a limited amount of wetland riparian habitat that holds high fish value (8,493 m²).

The Project is expected to lead to PAD of 25,181 habitat units (HU) of mainstem freshwater habitat caused by the LNG Canada Project footprint and design considerations at the time of the completion of this technical report. The majority of these mainstem losses will occur in Beaver Creek. An additional 19,684 m² of PAD is estimated to occur in off-channel stream habitats with an additional 30,612 m² of wetland pond habitat that is considered to be accessible and of use by fish, based on field observations. The total expected PAD for all freshwater aquatic habitat therefore amounts to 75,477 m².

In addition to freshwater PAD, 23,502 m² of estuary habitat loss is expected to occur in the ESA due to the direct displacement of 7,714 m² of wetted estuary habitat and 15,788 m² of lower

quality salt marsh habitat that is seasonally flooded during spring tides only. The salt marsh is of low value to fish throughout the remainder of the year when the salt marsh dries up and leads to potential stranding of fish and possible mortality effects, due to both stranding and predation.

This effects assessment has considered the realignment of Beaver Creek as a critical means to uphold connectivity between the estuary and the upper half of the system. This avoids additional PAD of upstream habitat due to flow obstruction by the Project footprint. Benthic productivity has not been examined in the affected system; rather, productivity has been based on relative abundance of juvenile CO at seasonal low flow conditions, given its ostensible use of the area as a seasonal refuge. Winter base flow conditions most likely represent the factor limiting annual productivity of the system; however, it will still be necessary in the Project's environmental assessment (EA) to determine which additional factors contribute to fish productivity in the affected area in the development of a mandatory offsetting program.

Base flow conditions in the Kitimat River also represent a legitimate risk to fish below the proposed intake for the Project, which would withdraw 70,000 m³/day of river water (LNG Canada 2013) from the mainstem, evaluated at a conservative instantaneous rate of withdrawal of 1.11 m³/s by Stantec (2014a). This is in addition to the 442,477 m³/day that is already diverted from 10 existing water licences. The water intake will occur upstream of the Haisla *Kitamaat* Indian Reserve (IR No.1) and the main area of traditional harvest for Eulachon (EU) *Thaleichthys pacificus*. Eulachon spawns in late winter/early spring during base flow conditions. Late summer/early fall base flow conditions correspond to annual spawning events for adult Pacific salmon species, including Chum Salmon (CM) *Oncorhynchus keta*, Pink Salmon (PK) *O. gorbuscha*, Sockeye Salmon (SK) *O. nerka* (river ecotype), and CO. Desktop analyses determined it is unlikely that adverse effects to instream flow requirements will occur downstream of the water intake, although infrequent drought conditions may require a curtailment of water use by the Project (Stantec, 2014a). Fish migration upstream of the water intake is not expected to be affected by water withdrawal, either due to incurrent forces at the water intake or loss of downstream connectivity; however, Triton recommends a field assessment of downstream habitats in the diversion reach as a supplementary measure to the desktop evaluation.

Effects in the form of *Serious Harm to Fish* from PAD of freshwater and estuarine habitat will require an Authorization under Paragraph 35(2)(b) of the federal *Fisheries Act* (2012). Potential options to be included in an offsetting plan will be constrained by a limited availability of land in the local area. This is particularly true for the estuary to the south of the proposed Project facility site, which is owned by Rio Tinto Alcan (RTA). *Kitamaat* IR No. 1 is located directly east of the Project along the Kitimat River and in a traditional area of annual EU harvest. Eulachon has been observed in this area in previous years (FISS 2013). Land formerly occupied by the Eurocan Pulp and Paper mill is located directly to the north of the Project and the IR, but is now owned by Kitimat LNG (KLNG) and contains previously disturbed aquatic habitat located next to the salmon hatchery, which is operated by Fisheries and Oceans Canada (DFO).

An offsetting strategy for the region involves combined interests based on the goals and objectives identified by all participants in the management decision process. Successful recovery of EU is an undisputed objective of the Haisla Nation and will likely serve as an over-arching

goal in the management process. Pacific salmon enhancement should also be prioritized in the LNG Canada offsetting plan. Collaboration with DFO might involve focused efforts to understand how offsetting measures can effectively enhance the fishery. LNG Canada should account for the decline in survival of juvenile CO due to the loss of rearing habitat. This is the most likely effect to result from the Project and should be the primary basis for developing meaningful offsets.

This report is rendered solely for the use of LNG Canada Development Inc. in connection with the LNG Canada Export Terminal Project, and no person may rely on it for any other purpose without Triton Environmental Consultants Limited's prior written approval. Should a third party use this report without approval, they shall not rely upon it. Triton accepts no responsibility for damages suffered by any third party as a result of decisions made or actions taken based on this report.

The objective of this report is to address an evaluation of the Freshwater and Estuarine Fish and Fish Habitat VC assessment of the Project based on information available at the time of its completion under the terms of the service agreement. This report is based on facts and opinions contained within the referenced documents and field information collected by Triton.

Based on professional judgment, Triton has identified and considered relevant facts and clearly identified assumptions and opinions pertaining to the scope of work, as of the time period during which the analyses have been conducted; however, Triton's opinion may change if new information is available or if any information relied upon has been altered. Triton applied accepted professional practices and standards in developing and interpreting data obtained by our field measurements, sampling effort, and observations.

This report should be considered in its entirety. Selecting only portions of the report for reliance may create a misleading view of the opinion held by Triton.

Document review tracking table:

<i>Date</i>	<i>Name</i>	<i>Action Performed</i>	<i>Status</i>
February 12, 2014	Chad Wilkinson	Initial draft document	Completed
February 14, 2014	Jesse Anaka	Q/A plus detailed review and editing	Completed
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1.0 Introduction

Freshwater and estuarine fish and fish habitat is a valued component (VC) to LNG Canada's EA application. Measurable parameters include the areal extent of fish habitat potentially affected by the Project (measured in m²) and the quality of fish habitat potentially affected (measured in habitat units; HU). Collectively, this determines the productivity of fish in the aquatic ecosystem within the LSA.

Direct effects to fish habitat include PAD of both wetted and riparian habitats from the Project footprint. Indirect effects include PAD to freshwater fish habitat due to the obstruction of waterways and changes in surface flows that lead to the impairment of critical life stage processes beyond the Project footprint. This includes migration into spawning, rearing, and overwintering habitats for all fish species of interest in consideration of life history timing. These changes can also affect habitat directly adjacent to the Project footprint and include changes in substrate quality and suitability of habitat for such life stage process.

Additional effects to be considered include the deposition of deleterious substances into adjacent and nearby fish bearing waterways as a result of Project-related activities and entrainment effects due to flow diversion and water use by the Project. These effects potentially lead to injury and mortality of fish and changes in fish health due to reduced water quality. All factors combined are considered in this assessment of effects from the LNG facility, according to its component phases:

- Construction;
- Operation; and
- Decommissioning.

2.0 Assessment Overview

The LSA includes both freshwater and estuarine habitats. Freshwater habitats include the following gazetted streams:

- Kitimat River (watershed code: 910-673500)
- Anderson Creek (watershed code: 910-673500-03300)
- Moore Creek (watershed code: 910-674000)

Anderson Creek is considered to be the main tributary of the Kitimat River based on its watershed code. Beaver Creek (ungazetted; watershed code 910-673500-03300), known to the Haisla as *Yaksda wa'wais* (Triton, 2012), is the main tributary of Anderson Creek and flows directly through the proposed Project footprint. Beaver Creek will be the aquatic habitat most affected by the Project. All these freshwater streams have varying degrees of off-channel habitat that is seasonally influenced by factors that determine habitat suitability. The primary factors are stage of stream discharge Q (i.e., surface hydrology) and seasonal changes in water quality, principally the availability of dissolved oxygen (DO).

Estuarine habitats include the large channels extending from the lowest reaches of these streams into Douglas Channel. An array of smaller, dendritic tidal channels extends into salt marsh habitat and is intertidally and seasonally flooded. These estuarine habitats are similarly affected by seasonal increases in upstream discharge and water quality parameters, principally the intermittent drop in salinity (‰), and have been observed to provide temporary habitat for juvenile Coho Salmon (CO) *Oncorhynchus kisutch* (Triton, 2014a).

2.1 Species of Interest

The technical data report (TDR) prepared for the EA indicates that numerous species of commercial, recreational, and Aboriginal (CRA) importance are found in freshwater and estuarine habitats of the local study area (LSA; Triton, 2014a). Distribution and relative abundance of these species are influenced by existing landscape modifications that have affected surface and possibly subsurface movement of water in the Lower Kitimat River estuary.

Table 2-1 lists the fish species of interest and life stages found in the LSA and the most relevant streams where they occur. These include six species of anadromous salmonids including CO, Chum Salmon (CM) *O. keta*, Pink Salmon (PK) *O. gorbuscha*, and river Sockeye Salmon (SK) *O. nerka*. Chinook Salmon (CH) *O. tsawytscha* and Steelhead Trout (ST) *O. mykiss* migrate up the Kitimat River to access spawning grounds, but the remaining species are all known to spawn in parts of the LSA. Juveniles for all species use both freshwater and estuarine habitats for rearing.

Freshwater salmonids present in the LSA include Rainbow Trout (RB) *O. mykiss*, Cutthroat Trout (CT) *O. clarkii clarkii*, and Dolly Varden Char (DV) *Salvelinus malma*, although CT and DV maybe also represent anadromous populations. Eulachon (EU) *Thaleichthys pacificus* is historically abundant in the Kitimat River and is a traditionally valuable fishery to the Haisla

Nation, which annually conducts EU surveys in the lower reaches of the Kitimat River, located in the LSA.

Table 2-1. Species of interest in major waterbodies of the LSA

Species	Code	Life Stage	Estuary	Kitimat R.	Moore Cr.	Anderson Cr.	Beaver Cr.
Chinook Salmon	CH	Juvenile	✓	✓		✓	✓
		Adult		✓			
Chum Salmon	CM	Juvenile	✓	✓	✓	✓	
		Adult		✓	✓	✓	
Pink Salmon	PK	Juvenile	✓	✓	✓	✓	
		Adult		✓	✓	✓	
Sockeye Salmon	SK*	Juvenile	✓	✓			
		Adult		✓		✓	
Coho Salmon	CO	Juvenile	✓	✓	✓	✓	✓
		Adult		✓	✓	✓	✓
Steelhead Trout	ST	Juvenile		✓			
		Adult		✓			
Rainbow Trout	RB	Juvenile		✓	✓	✓	✓
		Adult		✓	✓	✓	✓
Cutthroat Trout	CT	Juvenile		✓	✓		✓
		Adult		✓	✓		✓
Dolly Varden	DV	Juvenile		✓		✓	✓
		Adult		✓		✓	✓
Eulachon	EU	Juvenile		✓			
		Adult		✓			

Note: *Adult Sockeye Salmon observed in Anderson Creek likely did not successfully spawn; juveniles have not been observed.

Other fish species include Threespine Stickleback (TSB) *Gasterosteus aculeatus*, Lamprey (L) *Lampetra spp.*, and numerous sculpins *Cottus spp.*, which are found throughout the freshwater component of the LSA. Pacific Staghorn Sculpin (CLA) *Leptocottus armatus* was most commonly observed species in the estuary, followed by TSB, at all life stages and all seasons in estuarine tidal channels (Triton, 2014a).

2.2 Potential Project Effects

A Pathway of Effects (POE) diagram (Figure 2-1) has been assembled for the Project using the risk management framework developed by DFO (2010). It presents the type of activities proposed for each phase of the Project, known stressors associated with each activity, and the potential effects on freshwater and estuarine fish and fish habitats leading to *Serious Harm to Fish*. The purpose of the diagram is to illustrate causal relationships between the Project and the potential environmental effects identified. Each pathway represents an area where mitigation measures can be applied minimize the potential for adverse environmental effects. Each anticipated activity listed in the POE diagram is projected for one of the component phases within lifespan of the Project and varies in:

- Context;
- Magnitude;
- Geographic extent;
- Duration;
- Frequency; and
- Reversibility.

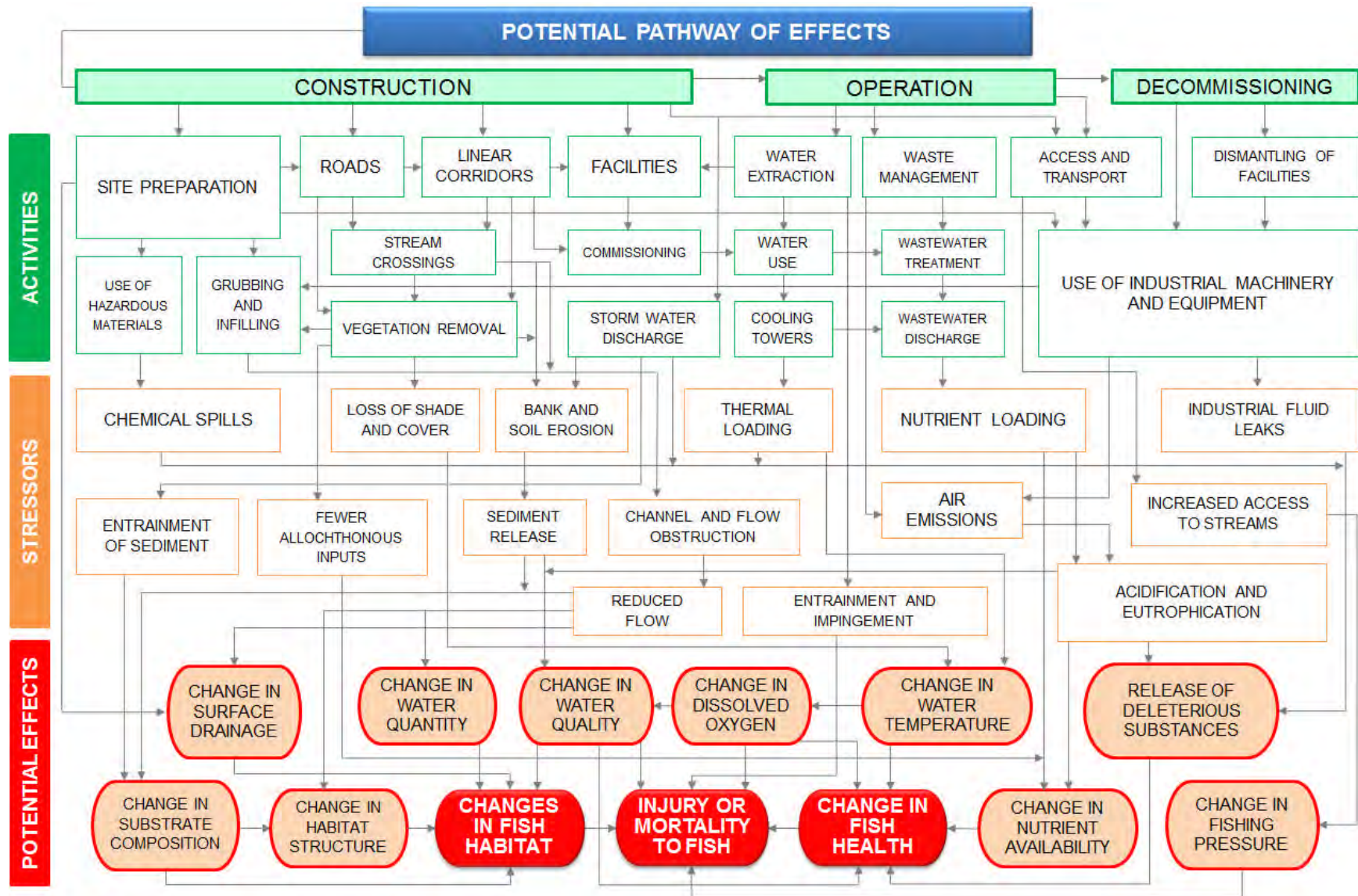


Figure 2-1. Pathway of effects diagram for the proposed LNG Canada Project

The construction phase consists of site preparation, road/pipeline construction and/or upgrades, temporary facilities, and assembly of permanent structures for the Project's operational lifespan. Associated activities have potential to impart stressors leading to effects in the aquatic environment. Site preparation will involve grubbing, infilling, and grading activities, which can lead to direct changes in aquatic habitat structure, substrate composition, and surface drainage patterns through numerous stressors including sediment release and flow obstruction. Habitat modifications can consequently affect the quality of spawning and rearing areas for fish. Release of fine sediment that becomes suspended in water can affect fish health through gill damage and reduced visibility. Sediment deposition into the substrate can reduce habitat suitability as it lowers both spawning capacity, both in terms of egg deposition and survival, and benthic productivity.

Vegetation clearing and soil compaction can impart stressors to riparian and aquatic habitats. Vegetation is important to maintain bank stability through the abatement of erosion. Removal of riparian vegetation can lead to erosion, increased surface runoff, and entrainment of organic and inorganic particles in waterways. Loss of riparian vegetation can reduce nutrients and allochthonous inputs that are important for fish production. It can also lead to reduced cover and shade. All these effects can lead to a reduction in fish health and survival.

Facility, road, and pipeline construction requires use of industrial machinery and can lead to terrain disturbance and the release of deleterious substances to fish bearing waterways. Hydrocarbons and hydraulic fluids can be toxic to fish if a leak or spill occurs near water, and operators must exercise care in following appropriate management practices to reduce any such risk. Stream crossings, such as clear-span bridges and box culverts, may be required in association with access road development. Equipment activity and the placement of clear-span bridge decks over watercourses can both compact underlying soil and increase the surface runoff leading to erosive effects. Installation of box culverts in a wetted channel can constrict flow and could lead to hydraulic effects that alter substrate and species composition due to changes in habitat suitability. Facility and crossing placement (whether road or pipeline) may also result in temporary flow obstructions affecting fish passage into upstream habitats due to site isolation.

Water use during the commissioning and operational phase will involve extraction from the Kitimat River and require some degree of effluent discharge to the marine receiving environment in vicinity of the estuary. Water extraction for cooling will reduce flows in the Kitimat River, which can potentially result in effects on migration due to reduced access to habitat upstream and within the Kitimat River's lower reach. Discharge of cooling water and gas hydrates extracted during the liquefaction process may lead to thermal loading in the marine and estuarine receiving environment, which can result in changes to water temperature and dissolved oxygen. Higher water temperatures may also adversely impact fish in the vicinity of the area of discharge, leading to avoidance or mortality. Higher temperature can also elevate microbial activity, thus increasing decomposition of organic matter leading to a reduction in DO.

Storm water discharge, during both the construction and operational phases, could lead to changes in suspended sediment and contaminant loading picked up by surface runoff in the Project area. Wastewater discharge and air emissions from industrial machinery and equipment may cause nutrient loading. Increased land and sea traffic during the facility's operational life

can result in increased contaminant concentrations through the release of deleterious substances. Changes in dissolved nutrient concentrations from air emissions can lead to eutrophication and acidification effects downstream and in waterbodies located nearby in the airshed. This may adversely affect aquatic vegetation, invertebrate production, and ultimately fish health. Increased access to streams may result in greater fishing pressure in the area.

Finally, activities during the decommissioning and reclamation phase may also have potential to impart stressors leading to effects in the aquatic environment. Employment of effective measures for site rehabilitation and remediation will reverse temporary effects from the Project incurred over its operational lifespan. Consideration should be taken of the time required for effective reclamation of the Project site as functional fish habitat, if this is the intended goal.

The potential for environmental effects to occur for the species of interest in Table 2-1 considers both temporal and spatial components. Seasonal presence of fish habitat and spatial organization of wetted habitat due to existing landscape modifications influence both the quality and quantity of aquatic habitat. Availability of off-channel habitat represents a substantive component of the total area affected (Triton, 2014a).

2.2.1 Seasonal Considerations

A seasonal assessment of fish production in the LSA consisted of site visits over the study period. Specific conditions revealed aspects of fish distribution associated with rearing, spawning, overwintering, spring migration of juvenile Pacific salmon, and the redistribution of fish during peak flow events in the Kitimat watershed (Table 2-2). Juvenile CO represents the most widespread species observed in the LSA (Triton, 2014a).

2.2.2 Spatial Considerations

Spatial complexity has resulted from direct efforts to stabilize natural hydrogeological processes in support of ongoing natural resource development in the area. Anthropogenic modifications include the construction of protective dikes; road, rail, pipeline, and other linear corridors; stream channelization through industrial sites; leachate from effluent lagoons; hatchery enhancement; landfills; and large industrial footprints, among other concurrent land uses. Spatial organization also includes the mainstem and off-channel habitats with limited accessibility to the tidal channels found in the estuarine habitat (see Appendix F-2).

2.2.2.1 Kitimat River

The lower 8 km portion of Reach 1 in the Kitimat River drains into Douglas Channel. Average water withdrawal is anticipated to be 70,000 m³/day (LNG Canada, 2013). A side channel system west of the mainstem interacts with the proposed Project footprint. On the upstream end, an active side channel flows from the mainstem off the right bank about 2.6 km downstream of the proposed water intake into an oxbow channel. Ponds that extend south off the channel toward the estuary have been previously blocked off by the 2-km long dike. Ponding that has occurred against the dike's east bank is known to seasonally trap juvenile CO (Jacobs, pers. comm.). All surface connectivity to Moore Creek, Anderson Creek, and the estuary tidal channels has been lost due to the dike.

Table 2-2. Seasonal assessment of freshwater fish production in the LSA (2012-2013)

Season	Month	Abiotic Conditions	Biotic Conditions
Late Spring	May	<ul style="list-style-type: none"> • Intermediate to high flows • Moderate freshwater off-channel habitat • Warming temperatures • Moderate off-channel DO 	<ul style="list-style-type: none"> • Fry/smolt seaward migrations (all anadromous species) • Residence in estuary tidal channels (CM/CO/CH/TSB/CLA) • Rearing in freshwater off-channel habitats (CO/RB/DV/TSB)
Early Summer	June	<ul style="list-style-type: none"> • Peak spring freshet • Maximal wetted freshwater off-channel habitat • Warming temperatures • Moderate off-channel DO 	<ul style="list-style-type: none"> • Residence in estuary tidal channels (CO/TSB/CLA) • Rearing in freshwater off-channel habitats (CO/RB/DV/TSB)
Late Summer	September	<ul style="list-style-type: none"> • Base flows • Minimal wetted freshwater off-channel habitat • Warm temperature • Minimal off-channel DO 	<ul style="list-style-type: none"> • Spawning (PK/SK/CO) • Residence in estuary tidal channels (TSB/CLA) • Rearing in freshwater off-channel habitats (CO/RB/DV/TSB)
Fall	October	<ul style="list-style-type: none"> • Peak flows • Maximal wetted freshwater off-channel habitat • Cool temperature • Moderate off-channel DO 	<ul style="list-style-type: none"> • Spawning (CO) • Residence in estuary tidal channels (CO/TSB/CLA) • Migration to winter habitats (all species)
Late Fall	December	<ul style="list-style-type: none"> • Intermediate to base flows • Moderate to low freshwater off-channel habitat • Cool temperatures • Low off-channel DO 	<ul style="list-style-type: none"> • Residence in estuary tidal channels (TSB/CLA) • Migration to winter habitats (all species)
Winter	January	<ul style="list-style-type: none"> • Base flows • Low wetted freshwater off-channel habitat • Cold temperatures • Low off-channel DO 	<ul style="list-style-type: none"> • Overwintering (all species) • Residence in estuary tidal channels (TSB/CLA)
Late Winter	March	<ul style="list-style-type: none"> • Base flows • Minimal wetted freshwater off-channel habitat • Cold temperatures • Minimal off-channel DO 	<ul style="list-style-type: none"> • Overwintering (all species) • Fry seaward migrations (CM/PK) • Residence in estuary tidal channels (CM/TSB/CLA)

2.2.2.2 Anderson Creek

Anderson Creek is the main tributary to the Kitimat River in the LSA; however, the dike prevents all surface interaction upstream of Douglas Channel. The main tributary of Anderson Creek is Beaver Creek, equally isolated by the dike from the Kitimat River. Anderson Creek enters the Project footprint on an alluvial fan that is slightly elevated in relation to the lower reach of Beaver Creek. Landscape modifications have affected surface interactions between Anderson and Beaver creeks. A number of side channels and sloughs provide surface and subsurface ‘cross-channel’ inputs to Beaver Creek from Anderson Creek upstream of the confluence (Figure 2-2).

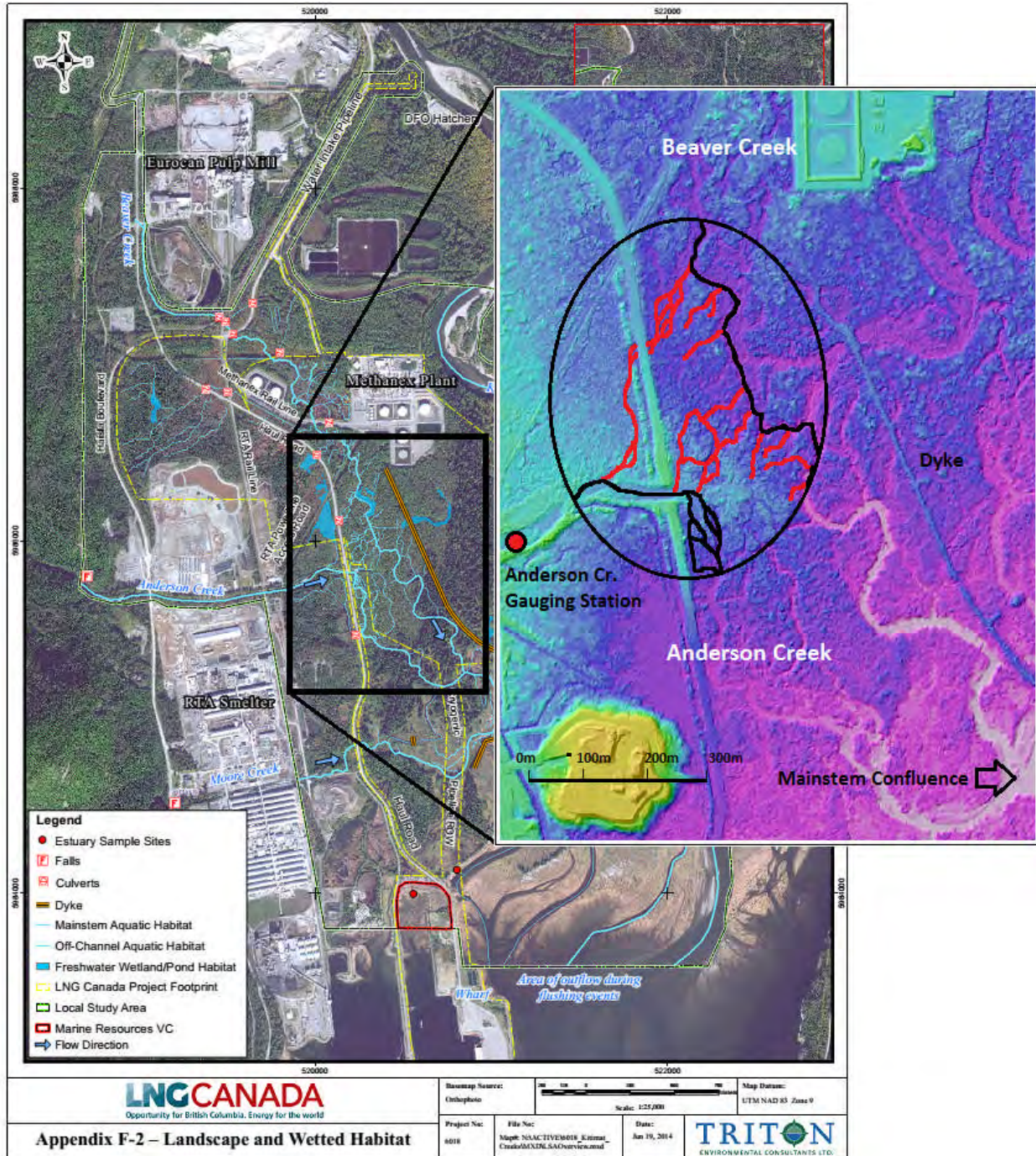


Figure 2-2. LiDAR image of cross-channel exchange (inset red) in the area of interaction between Anderson and Beaver creeks (inset black) upstream of the mainstem confluence

Anderson Creek’s mainstem does not directly interact with the Project footprint, but off-channel habitat extends into the footprint from both Anderson and Beaver creeks. Mainstem and off-channel losses will occur predominantly from Beaver Creek. A high percentage of the off-channel habitat is contained as standing water that extends into wetland complexes bordered

by elevated road, rail, and linear rights-of-way (ROWs; Appendix F-2). Overall seasonal connectivity is upheld by a limited number of discrete culverts.

2.2.2.3 Moore Creek

Moore Creek is a distinct stream from the Kitimat River. Additional smaller dikes also restrict connectivity of the mainstem from adjacent estuary channels and Anderson Creek upstream of the confluence. A pre-existing side channel connecting Moore Creek and Anderson Creek upstream of the mainstem confluence has been blocked by a small dike, but Moore Creek remains perennially connected to Anderson Creek as a single channel. No wetted habitat of Moore Creek will directly interact with the Project footprint, except at a proposed crossing along the LNG loading line and vapour return line ROW.

2.2.2.4 Kitimat River Estuary

The estuary receives distinct upstream freshwater input from a main channel draining the Kitimat River to the east. Additional large channels to the west also drain the combined inputs for Anderson and Moore creeks and remain hydraulically disconnected from Kitimat River throughout the entire salt marsh. Although they flow separately into Douglas Channel, a freshwater lens at the surface in Kitimat Arm permits a degree of interaction between habitats at the estuary. The interaction is likely greatest at peak flows when the salinity levels drop and may permit the movement of freshwater fish, including underdeveloped CO fry and parr flushed out of the Kitimat River, which migrate toward both the estuary channels and into Moore and Anderson Creeks.

Smaller dendritic tidal channels are temporary refuge for fish flushed from the freshwater system during peak flows, especially CO fry (Triton, 2014a), which can remain in the estuary until salinity levels increase enough to likely impart osmotic stress (see Section 3.3, Figure 3-8). Fry then will either retreat back up into freshwater habitats or perish. The channels connecting Anderson and Moore creeks are more readily accessible than the Kitimat River mainstem, suggesting that this part of the LSA may support a surplus of CO densities (i.e., additional fish sourced from the Kitimat River), compared to what is produced by spawners alone within the system. The rationale for such a working hypothesis is based on the combined observation of overall low number of adult CO spawners observed in Moore and Anderson creek and no spawning observed in Beaver Creek, despite a disproportionate amount of juveniles observed (Triton, 2014a). This working hypothesis supports a similar view held by the Haisla (Bolton, pers. comm.).

A portion of the estuary further west has been isolated from upstream freshwater inputs by a wharf extending >1 km off the salt marsh and into Douglas Channel. The wharf intercepts circulating ocean currents and obstructs freshwater inputs from the Kitimat River, except during spring freshet or heavy rain events in fall. Coho fry have been observed in the dendritic channels on the west side of the wharf following such events. All five species of juvenile Pacific salmon have also been observed here during seaward migrations. Chum Salmon was the most abundant species overall. Observations indicate this portion of the estuary becomes detrimental to freshwater fish that cannot retreat back into streams following flushing events and likely suffer from osmotic stress and ultimately perish. This disturbed part of the estuary will interact with the

Project footprint. A portion of wetted habitat directly to the east of the wharf will also be affected by the proposed LNG loading line ROW.

2.3 Effects Assessment

Following implementation of mitigation measures to reduce or remove aquatic effects identified in the POE model (Figure 2-1), PAD of fish habitat in a portion of the LSA can result from:

- Displacement of riparian habitat; and
- Displacement of wetted habitat.

Site preparation during the construction phase of the Project involves the removal of riparian habitat and infilling of streams and off-channel wetted habitat that cannot be avoided or mitigated and will require offsetting measures. The total area of the Project footprint that has been considered in this analysis is outlined in Appendix F-1.

Indirect effects include permanent habitat alteration in a portion of the LSA located outside of the Project footprint from such factors as:

- Changes in substrate quality and suitability; and
- Effects on migration of fish into upstream habitats.

Alteration of the Anderson Creek cross-channel wetted habitats that flow into to Beaver Creek and are adjacent to spawning habitats in Anderson Creek will result from the Project to varying degrees (Figure 2-2). Water withdrawal can potentially affect upstream accessibility by anadromous fish in the Kitimat River as well as smaller, elevated side channels and/or tributaries in the area of stream diversion.

2.3.1 Seasonal Considerations

Effects can be characterized by the seasonal variation as a determinant of the quantity and quality of fish habitat and potential effects posed by the Project. Variables include stream discharge, a key driver of off-channel habitat availability, as well as available DO given the physiological tolerance of the species of interest (salmonids).

2.3.2 Spatial Considerations

Effects can be characterized by a clear distinction between the wetted habitats on either side of the 2 km dike. The Kitimat River side channel system is isolated to the east side of this dike from the rest of the aquatic system extending to the estuary on the west side. It consists of a north channel section that flows from the Kitimat River mainstem into an oxbow channel, which in turn drains into a smaller south side channel, which is blocked by the dike (see Appendix F-2). The oxbow channel flows directly back into the Kitimat River mainstem. Moore and Anderson creeks and respective tributaries (i.e., Beaver Creek) and off-channel habitats are located to the west of the dike.

2.3.2.1 East of the Dike – Kitimat River Side Channel

Riparian Habitat

A portion of the Kitimat River mainstem at the water intake location and the side channel system west of the Kitimat River at the main LNG facility site will be subject to permanent loss of riparian habitat due to vegetation removal and grubbing for site preparation.

Wetted Habitat

The majority of the Project footprint is not likely to affect any wetted habitat along the Kitimat River mainstem. A portion of the Kitimat River side channel (KRSC) system will be permanently lost by infilling activities, effectively blocking flows from the side channel entrance to the north. Additional infilling will lead to habitat loss in the side channel to the south that is obstructed by the dike. A portion of this additional ponded area will be covered by the footprint.

Channel Obstruction and Confinement

Blockage of portions of KRSC habitat to the east of the dike will obstruct the side channel inputs from the Kitimat River and lead to habitat alteration at the upstream end. This will require realignment in order to maintain flow into the oxbow channel. Offsetting must therefore aim to restore flowing channels to prevent any habitat alteration from being permanent.

Water Withdrawal

Effects may result from water withdrawal at the proposed intake approximately 8 km upstream of the mouth of the Kitimat River. If instream flow requirements cannot be met during seasonal base flows, this will prevent access by migrating fish either to upstream habitats or into smaller side tributaries and off-channel habitats located along the diversion reach. This depends on the timing of life history requirements for the following species of interest:

- Anadromous salmonids (all species including ST, DV, and CT);
- Stream resident salmonids (RB, DV, and CT); and,
- Eulachon.

2.3.2.2 West of the Dike

Riparian Habitat Loss

The salt marsh on the west side of the dike contains an ESA that has been identified in the District of Kitimat Official Community Plan (Stantec, 2008). Effects consist of riparian incursions within estuarine wetland, mainstem channel, and off-channel habitats of lower Moore Creek by the proposed cryogenic LNG loading line and vapour return ROW. Additional estuarine stream and wetland riparian habitats extend up Anderson and Beaver creeks to the freshwater system within the Project footprint.

The majority of riparian losses are associated with stream habitat since a high percentage of wetland habitats is inaccessible and thus does not have value as fish habitat. The presence of

linear corridors and dikes has affected groundwater-fed ponds and wetland complexes that are hydraulically disconnected at all levels of stream discharge. Wetland riparian habitats that provide benefits to fish production, such as shade, cover, and allochthonous inputs from litterfall, have all been included as additional riparian habitat.

Wetted Habitat

A portion of wetted habitat west of the dike will be permanently lost by infilling activities due to site preparation during the construction phase. The majority of habitat loss and alteration will occur on Anderson Creek's main tributary, Beaver Creek. Much of the remaining losses will also occur on the side channels of both Anderson and Beaver creeks. Beaver Creek off-channel habitat upstream of all cross-channel inputs from Anderson Creek will also be lost due to the footprint (Appendix F-4a). A limited amount of wetted habitat alteration will occur on Moore Creek from the expanded Haul Road crossing. A portion of the estuary tidal channel located immediately east of the Haul Road and wharf will also be lost to this ROW (see Appendix F-4b).

Channel Obstruction and Confinement

The realignment of Beaver Creek constitutes a mandatory offsetting measure; otherwise the Project would preclude flow from Upper Beaver Creek and prevent access from the estuary to spawning and additional rearing habitat in Upper Beaver Creek. This would cause additional habitat alteration to Upper Beaver Creek, which thus requires alternate routing to maintain flow to the estuary. Every effort should be made to ensure Beaver Creek's stream integrity and hydraulic connectivity is maintained to support upstream spawning migration and outmigration of juvenile CO.

Alterations of the Anderson Creek 'cross-channel' habitat into Lower Beaver Creek (Figure 2-2) will also lead to confinement of flows to the mainstem channel of Lower Anderson Creek flowing off the alluvial fan. This increased flow may alter fish habitat due to changes in substrate composition. Sustained higher volume of flow through the mainstem channel of Anderson Creek may affect substrate composition through the removal of spawning gravels for smaller salmonids such as PK, RB, and DV, all of which are found in Anderson Creek. It is possible that.

Spring tides also flood salt marsh habitat directly north of the large estuary channel along the boundary of the LSA. Flooding provides access to estuarine fish; however, the marsh is likely to be a source of entrapment because it is only flooded by a single, narrow tidal channel (i.e., estuary Site EA-2; Triton, 2014a) during the spring tides. It remains mostly dry and totally disconnected from the large estuary channel for the remainder of the year. A bund specially designed for the elevated LNG loading line will allow for breaks that do not interfere with this hydraulic connectivity. Additional wetted estuarine habitat west of the wharf will also be affected by the Project due to land improvements for the marine offloading facility; however, the effects assessment of this estuarine habitat has been dealt with in the Marine Resources VC for the Project's EA and is not discussed further in this report.

2.4 Cumulative Interactions

A portion of the list of potential effects identified in the POE model can either be reduced to levels that are negligible with the appropriate level of mitigation. Historical development in the

LSA and regional study area (RSA) along with the current number of development proposals and any future resource development proposals all represent potential for cumulative effects to occur from the Project. This has implications on interactions among VCs identified in the EA together with environmental risks that occur at a larger scale and over the long term. For the Freshwater and Estuarine Fish and Fish Habitat VC, residual effects listed in Section 2.4 represent potential cumulative interactions.

During the operation phase, the liquefaction process and industrial activities associated with the Project will also contribute greenhouse gases and other emissions to the airshed, including sulfur dioxide (SO₂) and nitrogen oxides (NO_x). Air quality and water quality interactions can lead to large-scale effects to fish and fish habitat over the long term. The principal factors considered are eutrophication and acidification of waterbodies in the RSA, which have been addressed as separately, based on Air Quality and Surface Water Quality VCs, for the EA.

Operational water use for cooling during the liquefaction process will continuously withdraw an expected average of 70,000 m³/day of water from the Kitimat River over the operational lifespan of the Project. Water used for cooling will be combined with a liquids extraction process to remove gas hydrates from incoming natural gas feedstock prior to liquefaction. Depending on the amount of wastewater discharge expected from the Project, this might lead to effects on water quality in vicinity of the outfall, due to pollution or changes in temperature. Such changes to water quality in the marine environment would potentially cause toxicity effects on marine fisheries, and by extension, estuarine fisheries.

Assessment of whether such factors will lead to significant adverse effects to Freshwater and Estuarine Fish and Fish Habitat VC is based on the results from the Air Quality, Water Quality VCs for the Project's EA. Water quality interactions that occur in the marine environment, such as the discharge of wastewater effluent, temperature loading, ballast water interactions, dredging, and other activities have been addressed in the Marine Resources VC. Should any of the activities lead to effects in the marine environment, they must also be discussed in terms of estuarine interactions in the Freshwater and Estuarine Fish and Fish Habitat VC of the Project's EA.

2.4.1 Water Availability

Water allocation is determined on a cumulative basis in consideration of any Water Licence Application. Flow diversion from the Kitimat River is a primary activity where cumulative effects may occur. Multiple water licences currently extract a total of 442,477 m³/day from the river (Table 2-3) and LNG Canada proposes to divert an additional 70,000 m³/day (0.810 m³/s). Stantec (2014a) conducted an assessment of water availability using the Alberta Desktop Method (Locke and Paul, 2011) with modifications from the BC Oil and Gas Commission (OGC). Stantec (2014a) assumed a water demand of 1.11 m³/s for the Project. Mean annual discharge is 133 m³/s with a minimum of 9.3 m³/s and 7Q10 of 12.4 m³/s and 7Q20 of 10.7 m³/s (minimum flow over 7 consecutive days within 10- and 20-year periods, respectively; Stantec, 2014a).

Stantec (2014a) estimated a maximum percent reduction in the Kitimat River, given the increase in water use from the Project, to be 11.6% during the month of February, which represents the

lowest mean monthly discharge for the river. This fell within a condition of the method (i.e., Ecosystem Base Flow Condition 1) that cumulative water withdrawal shall not exceed 15% reduction of natural flow (Locke and Paul, 2011), which was considered in terms of mean monthly discharge. The assessment concluded that the additional water extraction would not lead to adverse effects under average hydrologic conditions; however, drought conditions still represent an environmental risk that could lead to water restrictions (Stantec, 2014a).

Table 2-3. Water licences and withdrawal rates for the mainstem Kitimat River

Stream/River	Licensee	Quantity (m³/day)
Kitimat River	Local Waterworks Authority	4,546.09
	Local Waterworks Authority	13,638.27
	Local Waterworks Authority	363.69
	Local Waterworks Authority	363.69
	YCS Holdings	113.65
	DFO Hatchery	109,728.00
	0892818 BC Ltd.	37.73
	0892818 BC Ltd.	32.88
	Rio Tinto Alcan	171,260.35
	Rio Tinto Alcan	122,393.02
Total		422,477.37

3.0 Methods

The analytical approach for estimating expected PAD has been based on information in the TDR for the Freshwater and Estuarine Fish and Fish Habitat VC assessment (Triton, 2014a) and the corresponding hydrologic investigation (Triton, 2014b) for the EA. Results corroborate with traditional ecological knowledge (TEK) provided by members of the Haisla Nation in terms of the fisheries values understood in the area west of the dike, also known as *Yaksda*, or the Beaver Clan Area (Triton, 2012). Additional information was collected during a final site visit in December 2013 prior to the completion of this assessment.

Additional fieldwork conducted in December 2013 resulted from a need to assess additional information about abiotic variables that influence fish habitat availability and suitability over winter. Triton founded its rationale on the working hypothesis that unique factors contribute to productivity in the LSA and likely provide a surplus of fish from inputs from the estuary, but produced elsewhere in the Kitimat River during peak flow events. Total annual fish production is then constrained by the capacity for these fish to successfully overwinter in the LSA during base flow conditions. Limited availability of such habitats would lead to use by fish of available peripheral side channel and wetland habitats that are prone to seasonally hypoxic conditions, thereby increasing the risk of mortality. Based on the fish observations, juvenile CO appears to be the most important species and life stage in the LSA west of the dike. Chum Salmon and CO are both evident on the east side, but these habitats do not appear to be as valuable overall and are likely to have been historically more important to EU prior to a decline in abundance, based on previous observations (FISS, 2013; Triton, 2014a). Detailed methods and rationale have been discussed in this section.

3.1 Project Specifications

The Project is defined by two separate aspects for the purposes of the EA:

- LNG production facility; and
- LNG shipping.

Shipping pertains to all activities that take place outside the freshwater and estuarine fish and fish habitat LSA; it has therefore not been considered in the VC assessment for the Project. The LNG facility has been further specified in this assessment according to its component phases:

- Construction;
- Operation; and
- Decommissioning.

3.1.1 Construction Phase

The construction phase will include all land clearing activities needed for site preparation within the Project footprint. Additional land preparation within the footprint must be allocated as a laydown area on the west side of Beaver Creek for storage of construction equipment and structural components prior to assembly at final locations within the main LNG facility footprint.

Dredge activities associated with the shipping aspects will require disposal of marine sediments that is not expected to occur upland at sites within the Project footprint. A 5,500-person construction camp and offices are planned further west of the laydown area and is considered to be part of the Project footprint. Activities at the end of the construction phase are associated with commissioning and start-up of the Project. Commissioning will involve hydrostatic testing of pipelines and associated infrastructure and represents initial interaction with the Kitimat River due to water withdrawal.

It is expected that all the necessary permits and licences for the construction phase of the Project will be obtained prior to the commencement of any activities that will lead to effects identified in Sections 2.2 and 2.3. The issuance of such permits must be based on an acceptable environmental management system (EMS) and outlined in approved environmental management plans (EMPs) that ensure that potential effects to the Freshwater and Estuarine Fish and Fish Habitat VC posed by the Project will be appropriately mitigated. Mitigation measures outlined in the construction environmental management plan (CEMP) minimize effects such that relevant authorizations and appropriate levels of monitoring will be necessary.

3.1.1.1 Authorizations

The Authorization under Paragraph 35(2)(b) of the federal *Fisheries Act* (2012) is the principal basis for evaluating effects to fish habitat. The Waste Discharge Authorization under the *Environmental Management Act* may be necessary for addressing potential effects related to water withdrawal and waste management under the Proponent's Water Licence, which is a requirement for the Project under the provincial *Water Act*.

3.1.2 Operational Phase

As with the application of appropriate mitigation measures under the EMP, the EMS must address additional effects during the operational phase through acceptable mitigation measures included in an approved operational environmental management plan (OEMP). The OEMP will require monitoring of any new or persistent effects associated with the water use and energy production for liquefaction (if natural gas is used on-site to generate electricity), transportation and other air emissions, and wastewater discharge. This will reduce the risk of long-term or large-scale effects on water quality due to eutrophication and acidification in nearby fish-bearing waterbodies. Such effects are of particular relevance to the assessment of cumulative effects.

3.1.2.1 Air Quality

Changes to fish health may occur if deleterious inputs associated with changes in air quality result from increased emissions caused by both the LNG facility and LNG shipping aspects of the Project. Emissions will result from gas-fired energy production at the facility for the liquefaction process, use of vehicles and other industrial equipment related to the liquefaction process, flaring of waste gas, and all other associated LNG production activities. Emissions will also result from the increase in tidewater vessel traffic associated with the LNG shipping aspect.

Assessment of air emissions as relevant to the Freshwater and Estuarine Fish and Fish Habitat VC depends on these factors:

- Chemical nature of air emissions;
- Meteorological factors in the airshed; and
- Potential for deposition to occur.

Types of emissions include, but are not limited to, oxides from nitrogen (NO_x) and sulfur dioxide (SO₂), as well as from greenhouse gases (e.g., CH₄, CO_x). Meteorological factors include prevailing wind direction and moisture content. Precipitation is the means by which deposition of emissions into nearby waterbodies occurs. This can lead to eutrophication and acidification effects. This information should all be assessed in modeling of air quality effects in order to inform the Surface Water Quality VC assessment before any effects to fish and fish habitat can be reasonably determined in the EA.

3.1.2.2 Water Quality

In terms of the Freshwater and Estuarine Fish and Fish Habitat VC, sources of potential water quality effects during the operational phase include handling and storage of hazardous materials, storm water surface runoff from the facility, and the handling of waste materials considered to be deleterious to fish (i.e., waste management). To prevent effects from occurring as a result of deleterious substance introduction, effects must be mitigated through the employment of best management practices (BMP) for hazardous materials (e.g., WHMIS) and the transportation of dangerous good (TDG; Transport Canada, 2014), erosion and sediment control (ESC), and waste handling associated with the Project's OEMP and authorizations.

Wastewater discharge to Douglas Channel includes all treated effluent from the water used in the cooling process along with the removal of gas hydrates from the natural gas feed prior to liquefaction, which will be sufficiently treated and reused, prior to discharge directly into the marine environment. The Marine Resources VC assessment would inform on any potential for residual effects to estuarine fish and fish habitat. Parameters of interest include concentration of solutes due to evaporative effects during the cooling process, and elevation in temperature in the marine receiving environment, above ambient conditions near the outfall.

Deposition of pollutants from emissions into nearby freshwater waterbodies can lead to changes in concentrations of dissolved species of pollutants. Critical load exceedances can lead to acidification (for SO_x and NO_x) and eutrophication (NO_x only) and adversely affect fish and other aquatic biota (Stantec, 2014b), leading to the residual effect of a change in fish health. This represents a potential cumulative effect in the context of the large-scale and long-term development activities in the airshed and should be evaluated in the water quality modeling associated with the Surface Water Quality VC assessment for the Project's EA.

3.1.3 Decommissioning Phase

No residual effects are expected to results from Project decommissioning provided that the dismantling and removal of all Project components follows the appropriate measures to avoid the release of deleterious substance and employs effective ESC measures. Reclamation efforts will likely lead to benefits if they include the re-establishment of wetted and riparian fish habitats at

the Project site and ensure that contaminated sites are effectively remediated. Post-closure monitoring activities will also prevent an onset of residual environmental effects.

An effective recovery strategy aimed at restoring stream, wetland, and off-channel habitats, estuarine channels, the estuary salt marsh, and the re-establishment of functional riparian habitats should take a minimum of five years post-closure. LNG Canada should plan its recovery strategy prior to the end of the operational phase of the Project. Design of a functioning freshwater and estuarine ecosystem could be developed prior to site decommissioning and it may also be possible to undertake immediate actions to re-establish habitat that functions *as designed* within a year of post-closure follow-up, provided there are no major issues with site contamination; however, it will take several years of monitoring the recovery site to determine whether it functions *as ecologically intended* by the design.

3.2 Freshwater Aquatic Habitat

3.2.1 Mainstem Fish Habitat Assessment

A habitat evaluation procedure determined the amount of wetted habitat subject to PAD based on species deemed to be representative of fish production in the aquatic ecosystem. Emphasis has been on spatial considerations of the freshwater habitats on either side of the dike. Total available wetted habitat involved distinct analytical approaches for the estimation of mainstem and off-channel aquatic fish habitat. The mainstem modeling approach considered physical parameters that influence fish habitat suitability for the evaluation species.

3.2.1.1 Evaluation Species

Total amount of wetted habitat throughout the year considers relevant life stages of fish observed in the baseline examination in the LSA (Triton, 2014a). Adult Pacific salmon were not captured in the baseline investigation, but Triton observed spawners in the LSA during the fall 2012 and 2013 field sessions. Table 3-1 represents a refined list of species, which are deemed in the analysis to be *evaluation species*. The list also considers the life stage that most representative to the aquatic ecosystem, based on field observations.

Existing local knowledge indicates that EU has historically occupied habitats east of the dike prior to the precipitous decline in abundance that has occurred in recent decades (Moody, 2008). This assessment acknowledges the traditional importance of EU to the Haisla Nation; however, EU has not been directly observed in the system over the study period and could not be included in the analysis of fish habitat suitability parameters.

Habitat suitability indices (HSI) for the evaluation species are based on information from the BC Ministry of Environment (MOE) among other sources. The HSI curves relate to relative preferences by fish for a particular stream depth and velocity (Figure 3-1 to 3-7). Streambed substrate and cover scores have also been derived from existing sources, including McMahon (1983), Raleigh et al. (1984 and 1986; Raleigh and Nelson, 1985; Table 3-2 and Table 3-3), Ptolemy (2001), and WDFW (2004).

Table 3-1. Species considered in the evaluation of wetted habitat

<i>Spatial Area</i>	<i>Species</i>	<i>Life Stage</i>	<i>Rationale</i>
East of the Dike	CO	Juvenile and adult	Potential spawning; observed rearing and overwintering habitat
	CM	Juvenile and adult	Potential spawning; observed rearing during seaward migration
West of the Dike	CO	Juvenile and adult	Observed spawning, rearing, and overwintering habitat
	CM	Adult only	Spawning habitat; limited juvenile rearing in freshwater.
	PK	Adult only	Spawning habitat; limited juvenile rearing in freshwater.
	RB	Juvenile and adult	Potential spawning; observed rearing and overwintering habitat

For the purpose of the assessment, the evaluation species have been further factored in the analyses with an ultimate intent of determining which species is most representative of the overall productivity, given the unique seasonal and spatial characteristics of the LSA. Factors affecting fish production include both water chemistry and physical habitat parameters. Four habitat parameters determined habitat suitability for fish in mainstem channels:

- Water depth;
- Water velocity;
- Substrate; and
- Cover.

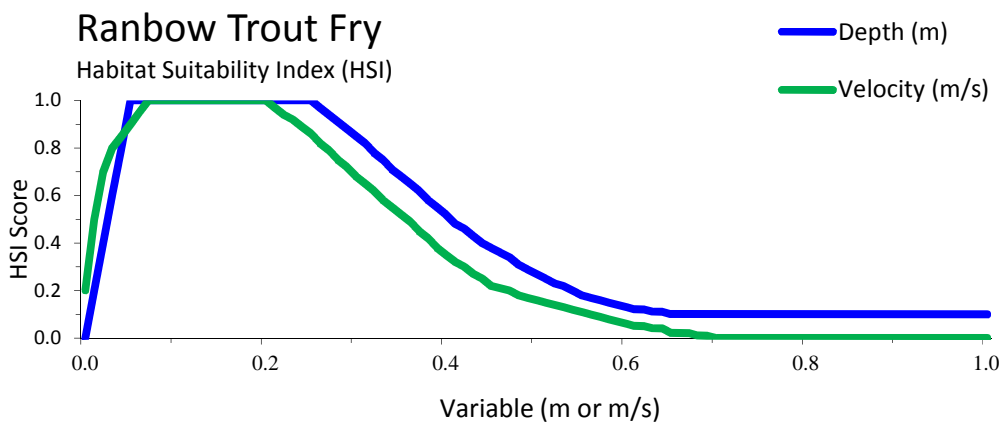


Figure 3-1. Rainbow Trout fry HSI curve

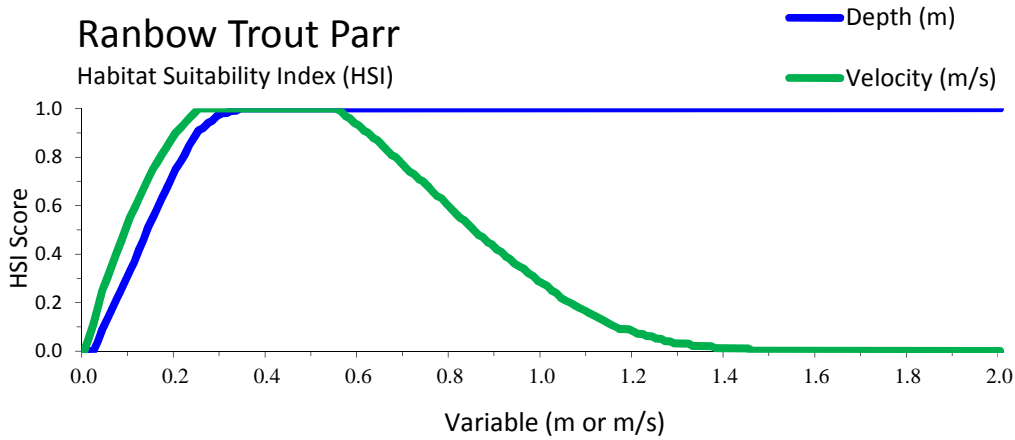


Figure 3-2. Rainbow Trout parr HSI curve

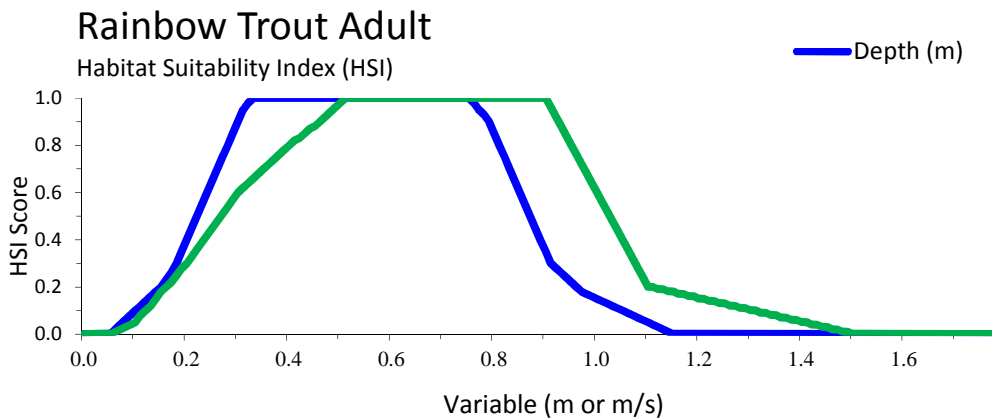


Figure 3-3. Rainbow Trout adult spawner HSI curve

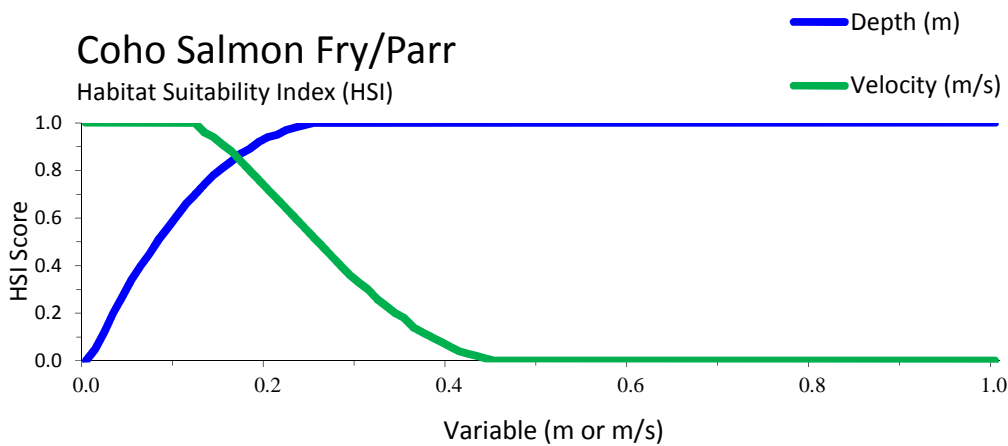


Figure 3-4. Coho Salmon fry and parr HSI curve

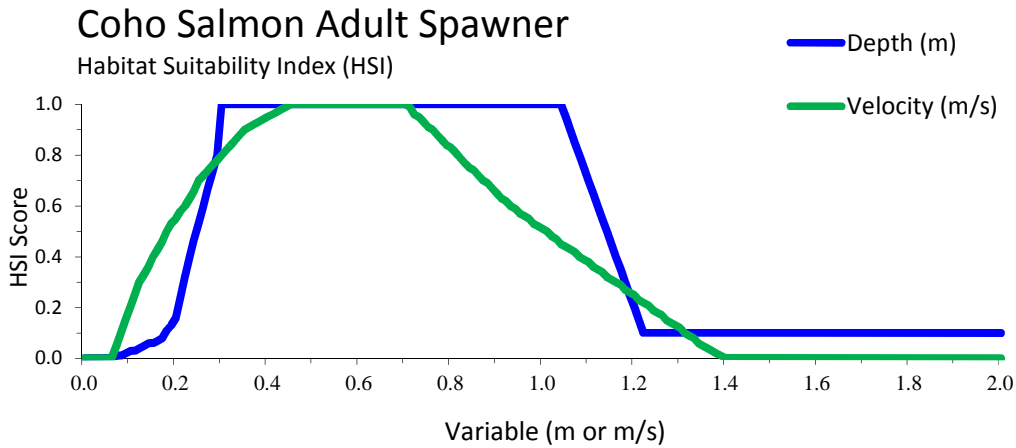


Figure 3-5. Coho Salmon adult spawner HSI curve

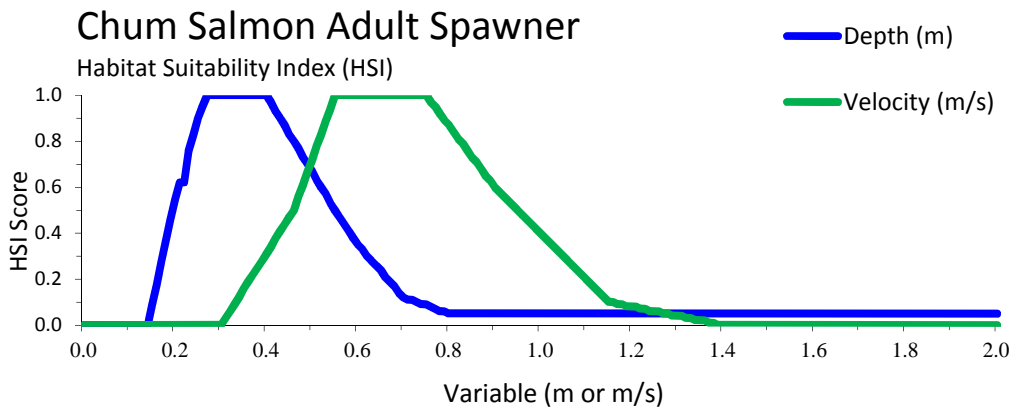


Figure 3-6. Chum Salmon Adult spawner HSI Curve

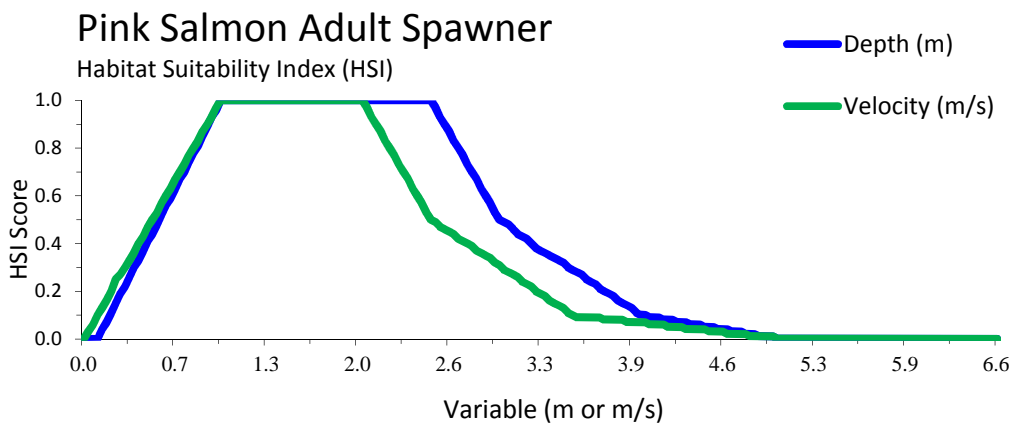


Figure 3-7. Pink Salmon adult spawner HSI curve

Table 3-2. Substrate HSI for CO, CM, PK, RB, in the LSA

<i>Habitat Parameter</i>	<i>CO</i>		<i>CM</i>	<i>PK</i>	<i>RB</i>		
	<i>Fry/Parr</i>	<i>Adult</i>	<i>Adult</i>	<i>Adult</i>	<i>Fry</i>	<i>Parr</i>	<i>Adult</i>
Substrate Preference							
Rock	0.20	0.00	0.00	0.00	0.20	0.40	0.00
Boulder	0.50	0.00	0.35	0.00	1.00	1.00	0.00
Large Cobble	0.70	0.00	0.62	0.00	1.00	0.80	0.00
Small Cobble	0.80	0.25	0.90	0.60	1.00	0.60	0.60
Large Gravel	1.00	1.00	1.00	1.00	1.00	0.50	1.00
Small Gravel	1.00	1.00	0.76	0.40	0.80	0.40	0.40
Sand/Silt	0.45	0.25	0.49	0.00	0.25	0.05	0.00
Detritus	0.30	0.00	0.00	0.00	0.05	0.05	0.00

Table 3-3. Cover HSI for CO, CM, PK, RB, in the LSA

<i>Habitat Parameter</i>	<i>CO</i>		<i>CM</i>	<i>PK</i>	<i>RB</i>		
	<i>Fry/Parr</i>	<i>Adult</i>	<i>Adult</i>	<i>Adult</i>	<i>Fry</i>	<i>Parr</i>	<i>Adult</i>
Cover Preference							
Undercut	1.00	1.00	1.00	1.00	0.50	0.30	1.00
Instream Submerged Vegetation	0.40	1.00	1.00	1.00	0.10	0.20	1.00
Instream Emerged Vegetation	0.40	1.00	1.00	1.00	0.10	0.20	1.00
Wood	1.00	1.00	1.00	1.00	0.80	0.20	1.00
Boulder	0.50	1.00	1.00	1.00	0.00	0.50	1.00
Overhanging Vegetation	0.10	1.00	1.00	1.00	0.25	0.05	1.00

3.2.1.2 Hydrologic Considerations

Seasonal Runoff

Peak flow in the Project area typically occurs during the spring freshet or in fall as a result of heavy rainfall. During the study period, maximum discharges were observed in October 2012. During this event the highest density of CO fry and parr (fork length > 35 mm) was also observed in the estuary channels in the LSA (Triton, 2014a). Annual low flows in the Project region generally occur in the late summer at the end of a dry period (i.e., September) and late winter to early spring period (i.e., March). Juvenile CO have not been observed in the LSA estuary system at these times.

Hydrology

Triton established discharge measurement and recording station (i.e., gauge station) on Anderson Creek above the area of surface flow exchange between Anderson and Beaver Creeks (refer to Figure 2-2) to provide hydrologic information for the Project. Twelve discharge measurements

taken at the hydrometric station yielded a rating curve used to develop a synthetic hydrograph for Anderson Creek (see Triton, 2014b), which has been a component of the ensuing habitat analyses. Triton (2014b) synthesized the hydrograph using information from the nearby Environment Canada gauge station (Hirsch Creek near the Mouth, Station #08FF002) and correlated the discharge information over its historic record to produce a series of annual hydrographs.

Triton (2014b) reviewed the data and prepared statistics for Anderson Creek to describe the annual runoff pattern (Figure 3-8) in terms of exceedance frequencies (i.e., 0%, 10%, 25%, 50%, 75%, 90%, and 100% exceedances) using the Anderson Creek synthetic discharge data.

Productivity

Based on concurrent hydrologic and fisheries programs, analysis of mainstem productivity in the Project footprint considered seasonal flows associated with late winter. Freshet occurs in late spring and fall. Such pulse flows appear to prematurely flush juvenile fish from the Kitimat River, which then remain in the estuary until salinity levels force them to retreat upstream or perish. The events occur in both spring and fall; however, flows associated with the fall freshet have the highest exceedance frequency (Figure 3-8).

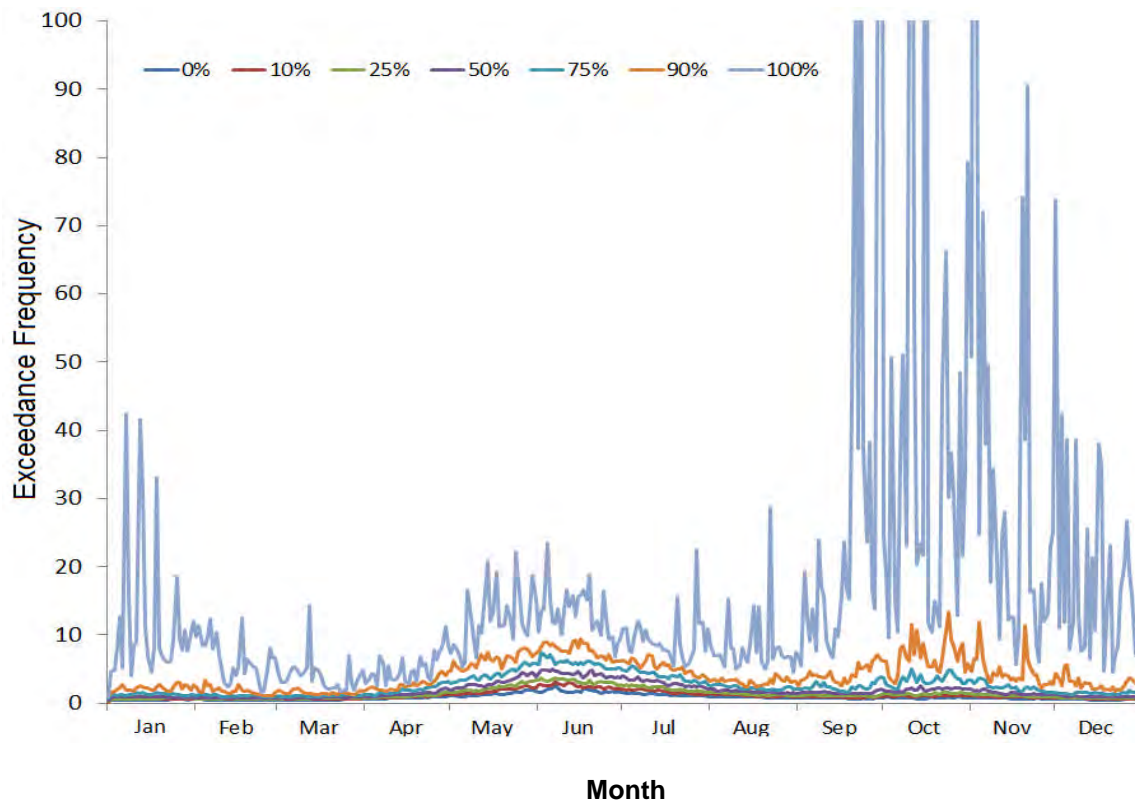


Figure 3-8. Exceedance frequency for Anderson Creek synthetic data (Triton, 2014b)

In the example of spring, on May 20, 2012, Triton observed 6 juvenile CH of a single cohort (FL = 86 to 88mm) in Reach 3 on Beaver Creek (9U 520194 5986527). This is a considerable

distance upstream of the estuary and CH is not known to spawn in any of the creeks west of the dike. These fish were therefore likely flushed downstream from the Kitimat River during the spring freshet.

The predominance of CO west of the dike and presence of juvenile CO fry in the estuary (Figure 3-9) following peak flow events suggest that total abundance in the streams in the Project area may represent a combination of native and upstream “pulse” out-migrants from spring and fall, such that the end of fall would comprise maximum fish abundance west of the dike. Juvenile CO would then be forced to remain in the system, constrained by the dike and saline conditions in the estuary over winter. The conditions would lead to reduction in flows and thus available habitat. For this reason, winter base flow conditions are considered the limiting factor in determining annual productivity of this part of the system.

East of the dike, a series of side channels are accessible from the Kitimat River mainstem through a perennially connected oxbow channel (Appendix F-2). The north channel of KRSC flows into this oxbow and is seasonally affected by changes in stream discharge. Downstream flow also continues from the oxbow channel into a south side channel that was historically connected to the estuary (Appendix F-2). This channel has been cut off by the dike thereby creating additional pond habitat. Upstream connectivity is lost during such winter base flow periods, but the ponds on the south end support juvenile CO year-round. Fish presence here is presumably determined by the same pulse flow conditions that affect juvenile CO downstream in the freshwater system west of the dike. Fish could be subject to entrapment effects in the ponds against the dike due to the loss of upstream connectivity with the oxbow channel during low flow periods. Fish habitat east of the dike has been similarly evaluated based on conditions during late winter for overwintering juvenile CO.

The mainstem assessment consisted of data collected at a number of discharge transects located at stations along Anderson, Beaver, and Moore creeks as well as within KRSC, the main channel east of the dike. Transects represented individual hydraulic channel unit types: riffle, run, and pool (refer to Triton, 2014a for survey methods). Triton applied Level-2 fish habitat assessment procedures (FHAP; Johnston and Slaney, 1996) to specific transect sites noting habitat parameters characterizing streambed substrate and cover for developing HSI-based models for use in the habitat evaluation procedure. Water depth D and velocity V measurements at each width increment, or cell, in the wetted cross-section of the channel assisted in characterizing hydraulic conditions across the wetted width W_w at each transect location.

These habitat parameters allowed for an extrapolation of both hydraulic (i.e., D and V) and cover information to determine weighted useable width WUW_T at each transect, which represented the portion of W_w considered to be suitable to the evaluation species. Quantifying habitat suitability at each transect is necessary for the evaluation of habitat units (HU) for all hydraulic channel unit types in affected mainstem channels.

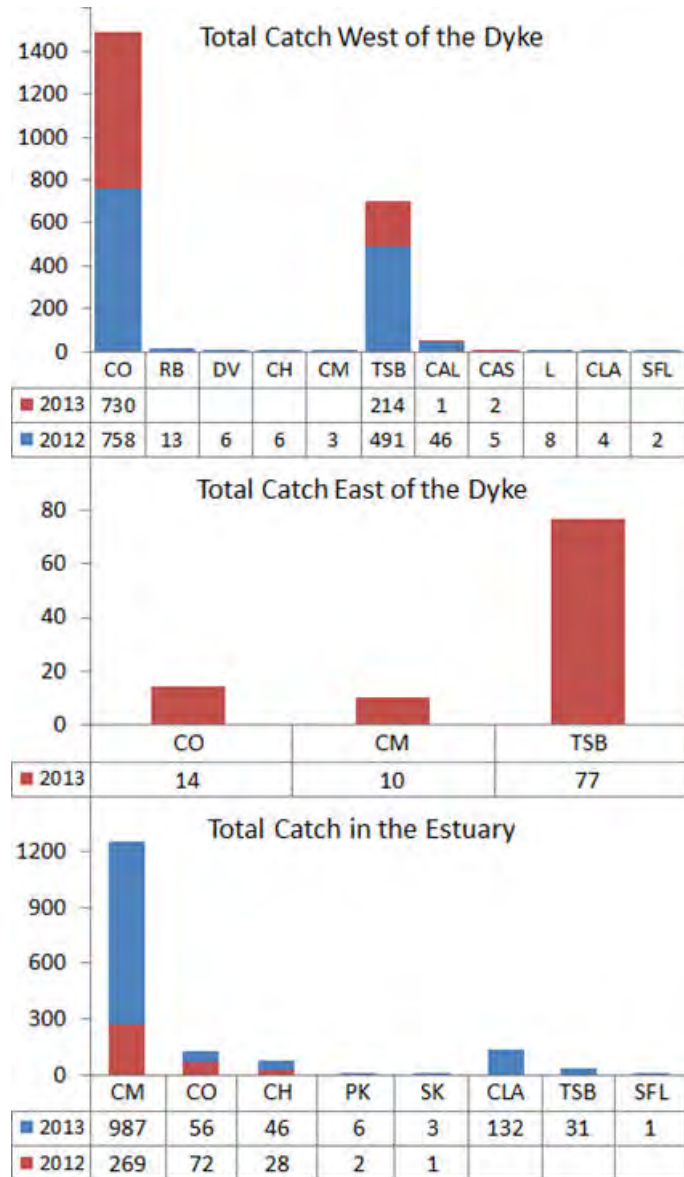


Figure 3-9. Catch summary by species in 2012 and 2013 in the LSA

3.2.1.3 Determination of Mainstem Weighted Usable Width

Triton determined the habitat suitability for life history requirements by applying HSI values associated with observed *D* and *V* along the transect to determine WUW_T for all evaluation species. Each transect WUW_T is based on specific HSI values, given the dominant bed substrate conditions:

$$WUW_T = \sum_{i=1}^{W_w} W_i D_i V_i S_i$$

Where W_i is the width of each cell increment *i* along a total W_w of the transect, and D_i and V_i are determined by the species-specific HSI values at cell *i*. Substrate suitability was also evaluated as

S_i based on species-specific substrate and cover preferences. The model assumed wetted width to be weighted as the sum-product of all habitat variables such that WUW approaches W_w as suitability increases to a maximum of 1 for D , V , and S at each increment i . Whenever necessary, the model extrapolated the mean D and V using a hydraulic model (see Reid, 2005) for cells that could not be directly measured due to extreme stream depths and/or velocities and deemed to be unsafe for direct measurement in the field.

3.2.1.4 Determination of Mainstem Habitat Units

The estimation of productivity capacity is based on available transect and FHAP data collected in the LSA. A number of assumptions have been made to address limitations and have been discussed in Sections 5.1 and 5.2. Triton used two approaches for extrapolating the total amount of habitat units HU in the system based the WUW calculations developed from specific HSI data.

The usable portion of the total wetted width of the channel at each transect was determined for each evaluation species using the HSI-specific habitat parameters. As a measure of suitability applied to a wetted area, the WUW can first be used to derive a ‘normalized’ HSI given total length of the wetted transect, or wetted width W_w :

$$HSI_{norm} = \frac{WUW}{W_w}$$

where HSI_{norm} is a dimensionless variable that represents the sum-product of all incremental widths adjusted according to HSI-specific scores and as a portion of the total W_w of the discharge transect. Extrapolation of the mean HSI_{norm} of each mesohabitat unit type across the total area observed in the Level-1 FHAP assumed transects to be representative of portion of the hydraulic channel unit type (i.e., riffle, run, or pool mesohabitats). These included the total mainstem wetted area W_A observed during the FHAP (e.g., see Figure 3-10).

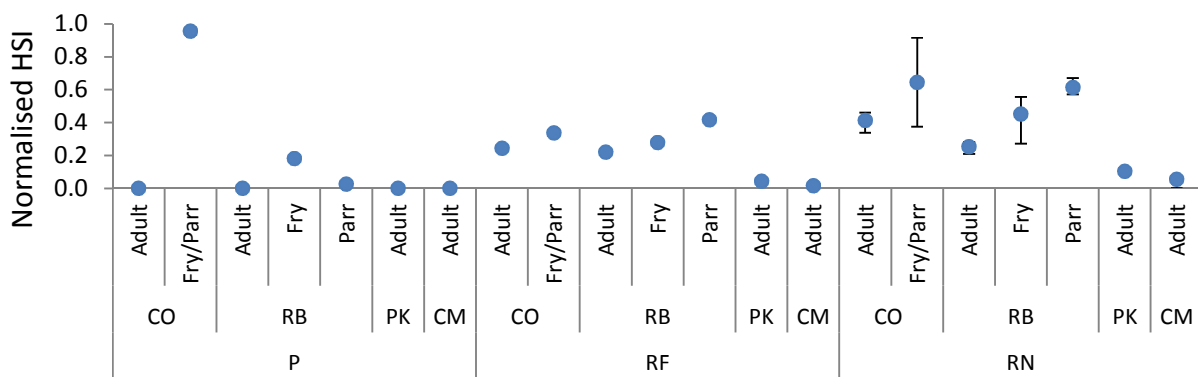


Figure 3-10. Means and standard deviations for normalized HSI for evaluation species in channel units of Beaver creeks

The next step was to determine the area of suitable fish habitat, or habitat units HU from the two approaches. Total wetted area W_A was considered along with HSI_{norm} . Total length L_n of stream

was considered using WUW for that particular hydraulic channel unit type n . Both approaches allowed for and an HSI-based areal estimate expressed as HU for each hydraulic channel unit type, based on the most representative species.

Triton examined the proportion of each unit type contained in the total wetted area W_A and total length L_n with Level-1 FHAPs conducted on each stream in the LSA over a range of seasons for all evaluation species. The seasonal assessment accounted for changes in the proportion of each hydraulic channel unit type associated with different stages of stream discharge (see Triton, 2014a). Respective amounts of HU in m^2 contained in the W_A and L_n of each individual hydraulic channel unit type is thus determined as:

$$HU = HSI_{norm} W_A$$

$$HU = L_n WUW$$

Triton repeated this procedure for the mainstem channels on all streams for each season included in the assessment. As no transects were located in pool habitat on Anderson Creek over the study period, the HSI_{norm} value used to determine HU for pool habitat in Anderson Creek was based on the Beaver Creek WUW values from the corresponding seasons as a surrogate for the portion of pool habitat found in Anderson Creek.

3.2.2 Off-channel Fish Habitat Assessment

In addition to mainstem habitat, a considerable amount of hydraulically connected wetted off-channel habitat exists in the Project footprint and is periodically available to fish. Total availability depends on seasonal flow conditions and is likely determined by both upstream surface and subsurface inputs. Availability of DO is also a principal limiting factor present in the system (Triton, 2014a).

Triton mapped out a subset of the off-channel habitats during field trips in September 2012, May 2013, and December 2013. Information supplied from the stream discharge gauging station on Anderson Creek, recent aerial photographs, and LiDAR imagery for the area (date of capture: August 2012) allowed for an informed estimation of off-channel aquatic habitat in the LSA.

Off-channel wetted habitats were categorized as either cross-channels (i.e., flowing from Anderson Creek into Beaver Creek), side channels, or blind channels (i.e., sloughs and groundwater inputs). During the surveys, Triton assessed channels to determine W_w , DO, length, hydraulic connectivity, and fish presence. Given the time-specific discharge for each set of field observations, it was possible to aggregate them into a total estimated W_A for off-channel fish habitat at a known discharge. The wetted area of each individual channel A_c has been considered a product of its length l and mean wetted width \overline{W}_w at the time of survey:

$$A_c = l_c \overline{W}_w$$

Total wetted off-channel habitat was determined as the sum of all channel types. For channels where W_w data were not available, Triton estimated W_A by using the mean W_w for all channels of the same category in the creek (Table 3-4).

Table 3-4. Mean \bar{W}_w values used for channels where no data were available

Mainstem Stream	Statistic	Off-channel Type		
		XC	SC	BC
Anderson Creek	n	14	16	6
	mean	2.38	2.19	1.24
	σ	1.25	0.80	0.52
Beaver Creek	n	N/A	13	33
	mean	N/A	3.34	2.55
	σ	N/A	1.63	1.68
Kitimat River Side Channel	n	N/A	29	39
	mean	N/A	2.71	2.35
	σ	N/A	1.35	1.62

Note: XC denotes cross-channel, SC denotes side-channel, and BC denotes blind channel.

3.2.2.1 Surface Discharge

Evaluation of available off-channel habitat considered upstream surface discharge Q_{Tt} at time t based on the synthetic hydrograph (Triton, 2014b). Total discharge Q_T represented the surface runoff for the entire catchment area C_T of both Beaver and Anderson creeks. It was therefore necessary to make the assumption that the ratio between Anderson Creek Q_A and Beaver Creek Q_B is proportional to the ratio of the total catchment area, C_A and C_B respectively, above the area of surface interaction.

$$Q_T = Q_A + Q_B$$

$$C_T = C_A + C_B$$

$$\frac{Q_A}{Q_B} \propto \frac{C_A}{C_B}$$

The total catchment area of Anderson and Beaver creeks C_T is known to be 4,959 ha and consists of $C_A = 4,473$ ha and $C_B = 486$ ha, such that Q_T has been described as follows:

$$Q_B = \frac{C_B Q_A}{C_A} = 0.11 Q_A$$

$$Q_T = 1.11 Q_A$$

Given the assumption of proportionality, it was then possible to estimate Q_{Tt} as the median daily discharge at time t for the corresponding off-channel site visits. Any functional relationship

between discharge Q_{Tt} and wetted area W_{At} could then theoretically be used to determine the wetted area of off-channel habitat:

$$W_{A_t} = f(Q_{T_t})$$

The field data consisted of three visits corresponding to specific values of Q_{Tt} during the investigation. Maximum area of off-channel habitat W_{Amax} was assumed to occur during the peak discharge event Q_{Tmax} associated with May 2013. Triton also noted the discharge during the May 2013 visit was most comparable to flows observed during June 2012 (Figure 3-11). The September 2012 Q_t most closely approached Q_{Tmin} , with off-channel habitat as the corresponding minimum wetted area W_{Amin} . The December 2013 visit represented an intermediate stage following fall freshet. Available data from each visit thus allowed for partial evaluation of available wetted habitat across a range of flows.

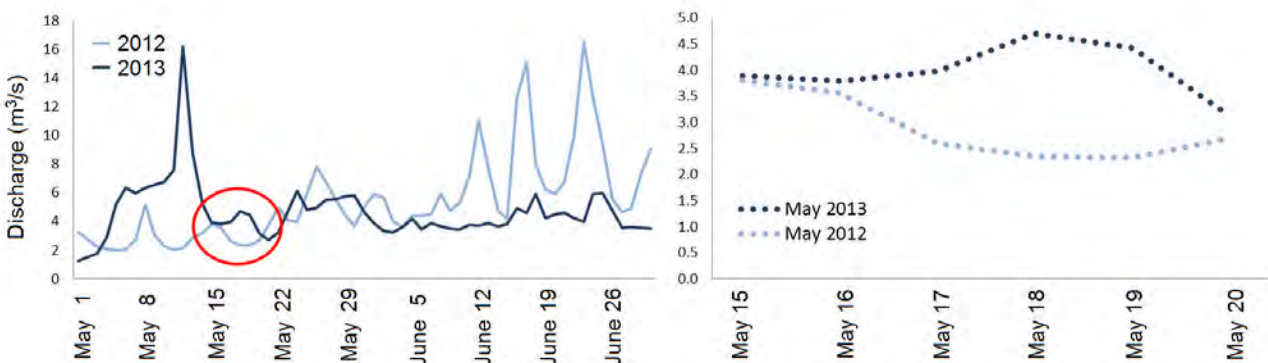


Figure 3-11. Anderson Creek discharge; red inset shows May 17-19, 2013 sample dates

3.2.2.2 Hydraulic Connectivity

During the September 2012 visit, Triton observed a portion of off-channel habitat to be ephemerally dry compared to observations during May 2013. Dry and disconnected channels reduce the total available off-channel habitat during Q_{Tmin} . Additional visits to a subset of sites in December 2013 allowed for Triton to ascertain the extent of “connectedness” of off-channel wetted habitat from the data at an intermediate discharge between Q_{Tmin} and Q_{Tmax} .

3.2.2.3 Dissolved Oxygen

Triton consistently observed a drop in DO levels away from the mainstem channels and into adjacent off-channel habitats. A similar pattern was evident in the arrangement of primary and secondary channels in an off-channel wetland complex of Beaver Creek, located in the northwest corner of the Project footprint (see Appendices D-1 and D-2). This pattern repeated at a reduced spatial scale, as DO dropped to hypoxic and anoxic conditions in secondary channels relative to well-oxygenated primary channels from which they extended (Figure 3-12). Through a process of elimination, Triton reduced off-channel availability from a theoretical maximum W_{Amax} in consideration of DO observed during the May 2013 and December 2013 field visits, in conjunction with the dry channel observations in September 2012 and December 2013 at reduced flows. Off-channel habitat was eliminated if the channel was dry or if DO levels were found to be below 5 mg/L.

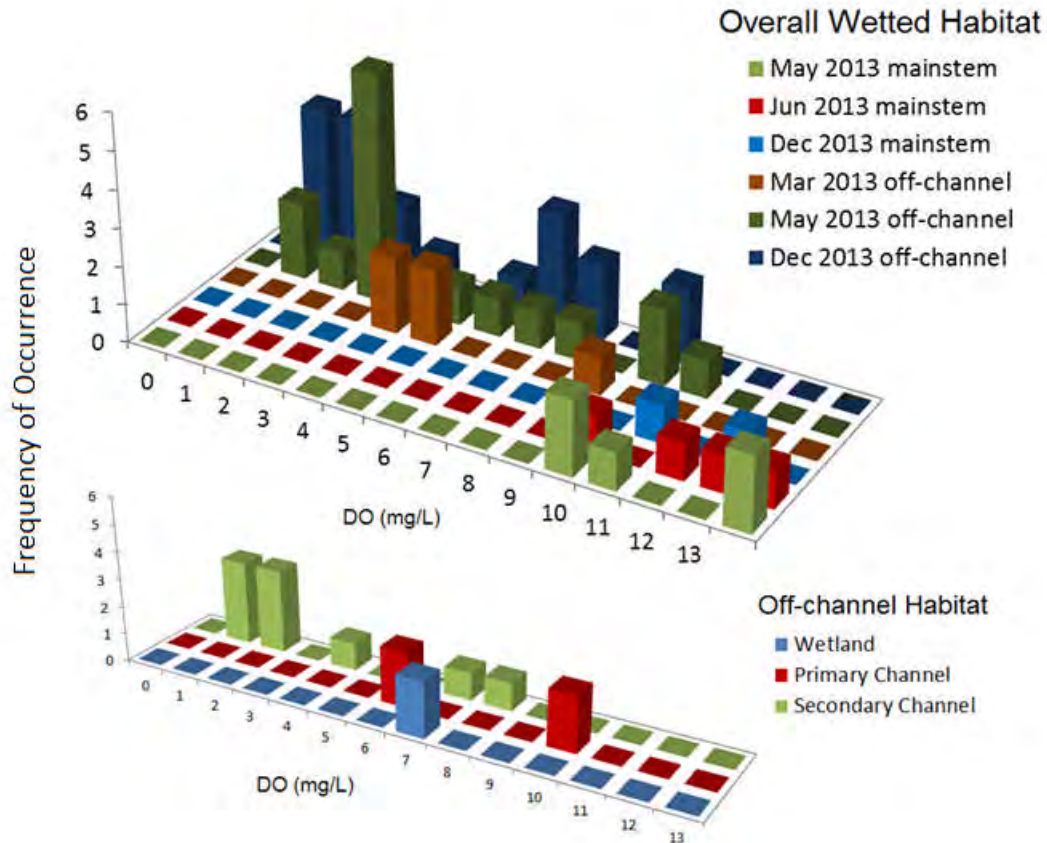


Figure 3-12. Frequency distribution of overall DO (main graph) and in an off-channel wetted habitat of reduced scale (lower graph) in the Project footprint

Total $W_{A_{max}}$ at $Q_{T_{max}}$ has been considered the maximum extent of off-channel wetted habitat in the LSA. Total W_A of off-channel fish habitat A_{off} was determined by summing the areas of all component channels with the areas of all adjacent wetlands found in each creek, then systematically eliminating channels determined to be unsuitable for fish from A_{max} at the time of off-channel evaluation. The extent of off-channel fish habitat could then be calculated by eliminating channels from the calculation of A_{off} if they were either dry or possessed DO levels observed to be below $5 \text{ mg/L } A_{hypoxia}$ at the time of survey:

$$A_{off} = \sum A_c + \sum A_{wetland} - \sum A_{dry} - \sum A_{hypoxia}$$

The off-channel habitat assessment was conducted for the channels and wetlands on the east and west sides of the dike.

3.2.2.4 West of the Dike

The portion of the LSA west of the dike is expected to be subject to the largest amount of direct fish habitat loss by the Project footprint and indirect effects of habitat alteration due to channel confinement and flow obstructions. Direct losses include Lower Beaver Creek's off-channel habitat contained in the footprint and Anderson Creek cross-channel habitat in vicinity of the

Haul Road Bridge. Additional Anderson Creek off-channel losses include the side channels on either side of the Reaches 2 and 3 as the creek flows south off the alluvial fan and east of the Haul Road (Appendices D-1 and D-2). The facility footprint will encroach on side channels to the east and the Haul Road expansion to the west will cut off a portion of the side channels directly along the west side of the mainstem of Anderson Creek.

3.2.2.5 East of the Dike

East of the dike, direct habitat losses will occur exclusively in KRSC; however, this area in the LSA is not affected by the discharge in Anderson Creek. Rather, discharge from Kitimat River would determine wetted availability in KRSC system. The correlation of flows during March 2013 was statistically significant ($p=0.00$; $R^2=0.63$) between Anderson Creek and the Environment Canada (EC) gauge station (08FF081 - Kitimat River below Hirsch Creek; Figure 3-13). Triton likewise used Q_{Ti} as a proxy for determining off-channel habitat east of the dike. March 2013 was considered the critical month in this analysis. March represents the period of base flows that have been determined as the limiting factor to annual productivity of juvenile CO, given the ecological considerations previously mentioned.

Direct habitat losses will occur in the Project footprint. Observations in September 2012 and December 2013 indicated that only a portion of the total number of active side channels and sloughs in the aquatic ecosystem are perennial. Final estimates for wetted off-channel habitat on either side of the dike have been summarized in Table 3-5.

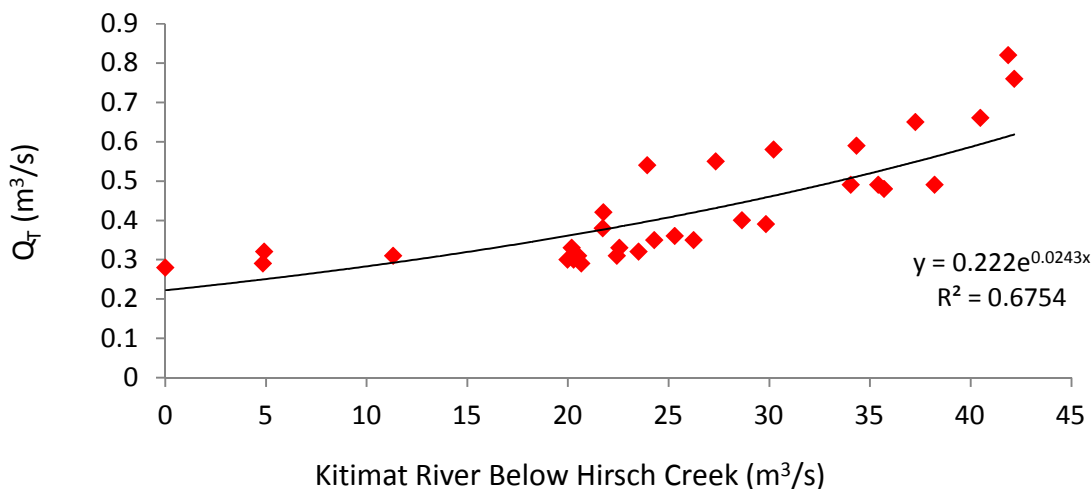


Figure 3-13. Correlation between Anderson Creek discharge Q_{Ti} and the EC gauge station on the Kitimat River for March 2013

Table 3-5. Estimated W_A for off-channel fish habitat losses

Month	Location	Creek	Effect	Channel Types			Channel Total	Wetland Total	Total W_A
				XC	SC	BC			
May 2013 (Q_{max})	E. of dike	KRSC	Loss	-	612	2,935	3,548	16,211	13,302
	West of dike	Anderson	Loss	6,249	2,933	739	9,921	-	9,921
		Beaver	Loss	-	7,639	20,737	28,376	14,401	42,777
May 2013 Total				6,249	11,184	24,409	41,845	30,612	72,457
Sept. 2012 (Q_{min})	E. of dike	KRSC	Loss	-	612	1,248	1,860	16,211	11,614
	West of dike	Anderson	Loss	3,580	1,634	-	5,213	-	5,213
		Beaver	Loss	-	4,969	7,872	12,841	14,401	27,242
September 2012 Total				3,580	7,215	9,118	19,914	30,612	50,526
Dec. 2013	E. of dike	KRSC	Loss	-	570	1,248	1,818	16,211	11,572
	West of dike	Anderson	Loss	3,580	1,620	-	5,200	-	5,200
		Beaver	Loss	-	4,969	10,274	15,242	14,401	29,643
December 2013 Total				3,580	7,159	11,521	22,260	30,612	52,872

3.2.2.6 Wetted Area as a Function of Discharge

Once estimates of W_A were determined for three seasons (May, September, and December), Triton assessed the functional relationship between W_{At} and Q_{Tt} . The aim was to use the functional relationship $f(Q_{Tt})$ to make estimates for the W_A for discharges in March 2013 (Figure 3-14) given known discharge at the Anderson Creek gauge station (Triton, 2014b). The model was best described by the following power function:

$$W_{A_t} = f(Q_{T_t}) = kQ_{T_t}^p$$

Coefficients k and p were derived for off-channel habitat excluding all wetlands, as the area of wetlands was assumed to be independent of surface discharge and more a function of groundwater input. Only wetlands considered to be sufficiently connected to stream habitat and with sufficient DO levels to support fish in December 2013 (i.e., winter season) were included in the March estimate.

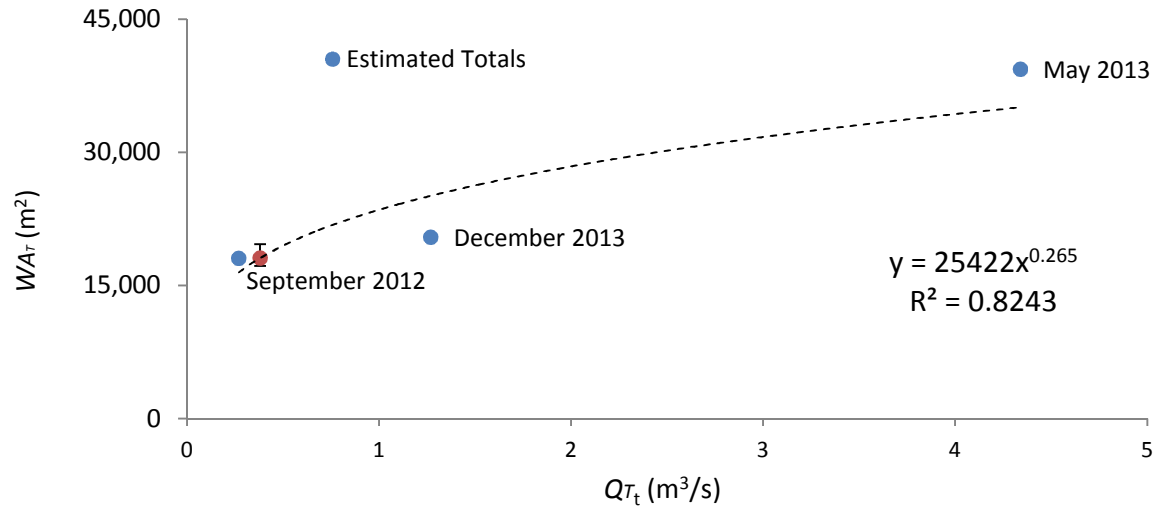


Figure 3-14. Functional relationship between wetted area W_{At} and discharge Q_{Tt} used to determined W_A for March 2013

3.3 Estuarine Aquatic Habitat

The evaluation of environmental effects in the ESA located on the Kitimat estuary also considered important temporal and spatial elements affecting the value of fish habitat. The layout of estuarine habitat affected by the Project footprint includes an intertidally wetted component and a seasonally wetted component that is subject to infrequent flooding during spring tides. The intertidal component includes all large channels and smaller tidal channels draining the surface of the salt marsh, treated as estuary habitat holding year-round fisheries value. Baseline results indicated seasonal use by salmonids as well as the regular presence of species that are part of CRA fisheries (e.g., juvenile CO) or species that support such fisheries (e.g., TSB; Triton, 2014a).

Salt marsh habitat is located along the south end of the LNG loading line ROW corridor. The area is mostly dry, but it does receive annual flooding events during spring tides and thus becomes accessible to estuarine fish species. The area remains flooded for an extended period due to a limited capacity for drainage, through a single narrow channel (i.e., Site EA-2; Triton 2014a) directly under the ROW. This salt marsh is not considered to have high fisheries value because of the potential for fish to become stranded following the spring tides. It has thus been categorized as a low-value “area of entrapment”.

Recall that all estuary habitat west of the wharf has been assessed as part of the Marine Resources VC (Appendix F-1), and has thus been excluded from this effects assessment. The baseline assessment did not involve any quantitative means to evaluate productivity of the estuary. All affected areas have been quantified based on areal calculations of both estuary channel at the upper tidal mark and the observed areas of entrapment following flooding events associated with spring tides. Permanent loss represents only the portion of estuary habitat that would be displaced by the Project footprint (i.e., the LNG loading line bund and the LNG facility footprint).

3.4 Riparian Habitat

The evaluation of riparian habitat for the effects assessment is based on data collected for the Freshwater and Estuarine Fish and Fish Habitat TDR (Triton, 2014a) and Vegetation Resources TDR (Stantec, 2014c). Wetted habitats include:

- Streams;
- Wetlands accessible to fish; and
- Estuarine tidal channels.

Estuarine tidal channels located west of the Haul Road have been included as part of the TDR (Triton, 2014a); however, this area of the estuary has not been considered in the effects assessment. The presence of the existing wharf has affected freshwater interaction from the Kitimat River and led to a prevalence of marine-like conditions. This area has been considered in terms of permanent habitat loss and is discussed in detail in the Marine Resources VC chapter of the EA (see Appendix F-1).

Triton has assumed that the area delineated by the Project footprint represents the total amount of land to be disturbed by the Project, unless specifically noted in discussions with LNG Canada. This includes the following elements as they pertain to freshwater and estuarine riparian habitat:

- LNG facility;
- Haul road upgrade; and
- Linear ROWs:
 - o Kitimat River water intake;
 - o LNG loading and vapour return lines.

The area of disturbance for the LNG loading line ROW will be substantially smaller than what has been delineated for the ROW (Appendix F-1). The corridor will be reduced to an expected width of 48 m and consists of a protective bund designed for spill containment in the event of a breach in the pipeline. The berm runs in parallel with the LNG loading line that sits elevated on pilings. There are expected to be breaks in the bund at watercourse crossings to maintain tidal channel and stream flows, but the cryogenic LNG loading line will continue across the watercourse approximately 5 m above the ground.

Additional footprints associated with the Project extend onto the proposed marine terminal. This portion of the facility falls outside of the Freshwater and Estuarine Fish and Fish Habitat VC LSA boundary and has not been considered in the assessment. Delineation of total riparian habitat has been considered for streams, wetlands of value to fish, and estuarine aquatic habitat. The leave strip is a standard setback of 30 m perpendicular to the edge of stream/estuary channel or wetland habitat, as determined by DFO (1993). The evaluation of expected riparian habitat losses in the estuary is distinguished from freshwater riparian habitat as part of the ESA delineated in the District of Kitimat Official Community Plan (Stantec, 2008). Estuarine riparian incursions in the Project Footprint are associated with a combination of both stream/channel and wetland/salt marsh habitats. The effects assessment thus acknowledges riparian habitat lost by the Project footprint in the estuary portion of the LSA to be part of this ESA.

4.0 Results

4.1 Freshwater Aquatic Habitat

Estimated PAD of aquatic habitat includes both mainstem and off-channel areas in the LSA and amounts to a total of **75,477 m²** including mainstem *HU* and off-channel areal estimates. Mainstem productivity has been based on habitat suitability for juvenile CO; however, mean values for *HSI_{norm}* and *WUW* for all evaluation species have been included in Appendices F-7 and F-8, respectively. The mainstem results have been stated in terms of m² and the adjusted *HU*. Table 4-1 summarizes totals of estimated mainstem wetted habitat for each affected stream, including the component amount for individual hydraulic channel unit types.

4.1.1 Mainstem Fish Habitat

Mainstem PAD of aquatic habitat for all affected streams includes a total wetted area of **41,544 m²** based on winter seasonal FHAP data (January 2013). This wetted total has been refined to be between 25,029 and 25,181 *HU*, based on the *WUW* and *HSI_{norm}* approaches, respectively. Total *HU* includes between 6,088 and 7,624 *HU* of pool habitat, between 1,949 and 2,050 *HU* of riffle habitat, and between 16,992 and 15,707 *HU* of run habitat based on respective *WUW* and *HSI_{norm}* estimation approaches (see Table 4-1).

Beaver Creek

Mainstem aquatic habitat loss in Beaver Creek includes a total wetted area of 25,343 m², refined to between 15,884 and 17,235 *HU* for *WUW* and *HSI_{norm}*, respectively. Total *HU* consists of between 4,424 and 6,612 *HU* of pool habitat, between 514 and 568 *HU* of riffle habitat, and between 10,946 and 10,055 *HU* of run habitat, based on respective *WUW* and *HSI_{norm}* estimation approaches for all mainstem habitat between the Anderson Creek confluence and Haisla Boulevard. Beaver Creek mainstem habitat upstream of Haisla Boulevard has not been evaluated because in this assessment due to limitations on access, but it nonetheless represents additional aquatic habitat loss that will result from the need to effectively realign Beaver Creek upstream of the Project footprint.

Anderson Creek

Mainstem aquatic habitat loss in Anderson Creek includes a total wetted area of 9,376 m², refined to between 3,952 and 4,115 *HU* for *HSI_{norm}* and *WUW*, respectively. Total *HU* consists of between 373 and 263 *HU* of pool habitat, between 1,242 and 1,368 *HU* of riffle habitat, and between 2,337 and 2,484 *HU* of run habitat, based on the respective *HSI_{norm}* and *WUW* estimation approaches.

Moore Creek

Mainstem aquatic habitat loss in Moore Creek includes a total wetted area of 608 m², further refined to between 416 and 540 *HU* for *HSI_{norm}* and *WUW*, respectively. Total *HU* consists of between 209 and 341 *HU* of pool habitat, between 67 and 37 *HU* of riffle habitat, and between 140 and 162 *HU* of run habitat, based on respective *HSI_{norm}* and *WUW* estimation approaches.

Table 4-1. Estimated W_A and HU loss for channel mainstem from winter FHAP data

Mainstem Stream	Total Wetted Area (m^2)				HU Area using HSI_{norm} (m^2)				HU Area using WUW (m^2)			
	P	RF	RN	Total	P	RF	RN	Total	P	RF	RN	Total
Mainstem Habitat Loss												
Beaver Creek	6,914	1,680	16,749	25,343	6,612	568	10,055	17,235	4,424	514	10,946	15,884
Anderson Creek	373	3,520	5,483	9,376	373	1,242	2,337	3,952	263	1,368	2,484	4,115
Moore Creek	210	198	200	608	209	67	140	416	341	37	162	540
KRSC	1,858	412	5,305	7,575	430	173	2,975	3,578	1,060	30	3,400	4,490
Total	9,355	5,810	27,737	41,544	7,624	2,050	15,707	25,181	6,088	1,949	16,992	25,029

Note: P = pool habitat; RF = riffle habitat, RN = run habitat.

Kitimat River Side Channel

Mainstem aquatic habitat loss in KRSC east of the dike includes the portion of the main side channel affected by the Project and mapped out during the December 2013 FHAP. Estimated loss includes a total wetted area of 7,575 m², refined to be between 3,578 and 4,490 HU for HSI_{norm} and WUW , respectively. Total HU consists of between 430 and 1,060 HU of pool habitat, between 173 and 30 HU of riffle habitat, and between 2,975 and 3,400 HU of run habitat based on respective HSI_{norm} and WUW estimation approaches.

4.1.2 Off-channel Fish Habitat

Estimated off-channel productivity has been based on total wetted area in the off-channel habitat (Appendix F-9). This includes hydraulically connected habitat observed to have suitable DO to support fish over winter. The estimation corresponds to median monthly discharge in March Q_{March} .

Streams

Based on the median monthly discharge for March 2013, the Project is expected to result in PAD of an estimated total of **19,684 m²** of freshwater off-channel stream habitat, through a range of 18,727 and 21,337 m² representing 25th and 75th percentiles, respectively. Of this total, 18,122 m² is estimated to be the loss incurred west of the dike, while an additional 1,562 m² is estimated to be the loss incurred east of the dike. Results for off-channel fish habitat are contained in Table 4-2.

Table 4-2. Expected PAD for off-channel habitat from Q_{Tt} estimates for March 2013

Off-channel PAD	Q_{March}	W_A West of the Dike	W_A East of the Dike	Total W_A
25 th percentile	0.3156 m ³ /s	17,248 m ²	1,479 m ²	18,727 m ²
Median	0.3810 m³/s	18,122 m²	1,562 m²	19,684 m²
75 th percentile	0.5165 m ³ /s	19,630 m ²	1,707 m ²	21,337 m ²

Wetlands

Total wetland losses are expected to be an additional **30,612 m²**, consisting of 14,401 m² west of the dike and 16,211 m² east of the dike.

4.2 Estuarine Aquatic Habitat

The Project is estimated to result in PAD of **23,502 m²** of fish habitat in the Kitimat estuary. Of the total loss, 7,714 m² represents wetted estuarine fish habitat. The remaining 15,788 m² is located in an area of entrapment considered to be of low fish value. Appendix F-5 shows the area of losses in the LSA.

4.3 Riparian Habitat

4.3.1 Freshwater

Based on standard DFO setbacks of 30 m along the wetted edge of affected aquatic habitat, the estimated loss of approximately **891,266 m²** of riparian habitat is expected. Of this total, 837,276 m² represents riparian habitat associated with streams. The remaining 53,990 m² accounts for riparian habitat around wetlands and ponds that would be considered to benefit fish at some life stage. Opportunities to develop riparian offsets must be explored as the habitat offsetting plan designs are refined.

4.3.2 Estuary

Estimated riparian habitat expected to be lost by the Project in the estuary, based on a standard DFO setback of 30 m for streams and wetlands of high fish value, is 20,494 m² and 8,493 m², respectively. This amounts to a total estimated loss of **28,987 m²** of estuarine riparian habitat (Appendix F-5).

5.0 Discussion

5.1 Assumptions and Limitations

Productivity has been defined in this assessment in consideration of the HSI values associated with juvenile CO. This is based on scientific observations of its predominance throughout the LSA relative to all other species of CRA importance. This conclusion corroborates with orally communicated local knowledge that the area known as *Yaksda wa'wais* is considered to be a refuge for CO that get flushed out of the Kitimat River (Bolton, pers. comm.). Physical parameters were involved in evaluating habitat suitability (i.e., depth velocity, substrate, and cover) as a defining component of productivity determined by *HU* in mainstem habitats, and areal estimates in suitable off-channel habitat and overall estuarine habitat. Data limitations for the estimation models used to determine *HU* in Beaver Creek and Anderson Creek mainstem are discussed further in this section.

Beaver Creek Mainstem Habitat Assessment

Fish habitat in Reach 3 (Start: 9U 520194 5986484) was not formally mapped but was observed to consist of two sections of homogeneous channel based on repeated observations and uniform stream gradient. The lower 300 m section from the start of the reach up to the culverts under the Methanex rail spur was considered to be continuous pool habitat with the W_w taken from transect BT4A (9U 520277 5986229), which is located in comparable pool habitat near the start of Reach 2 and is directly upstream of a beaver dam. The mean pool HSI_{norm} for CO fry/parr was then applied to the calculated area to estimate total mainstem pool habitat units. The upper 585 m long section between the railway line and the boundary of the Project footprint was considered to be continuous run habitat with a W_w likewise taken from transect BT1 (9U 519183 5987299) located in comparable run habitat further upstream. The mean run HSI_{norm} for CO fry/parr was then applied to estimate the mainstem run habitat units.

Anderson Creek Mainstem Habitat Assessment

The entire stream from the first cross-channel of Anderson Creek downstream to the confluence with Beaver Creek has been assessed in terms of the potential for habitat alteration due to the Project. Data representing HSI_{norm} from *WUW* were available for Anderson Creek, but have not been included in the overall evaluation of PAD. Localized FHAP information gathered for Anderson Creek has been used to estimate only a limited amount of mainstem habitat that will be affected by the expanded Haul Road bridge; however, it seems appropriate to consider the value of these data in the broader context of adaptive management and this has been appropriately discussed in the ensuing subsection.

Off-Channel Habitat Assessment

To determine wetted area of individual channels of unknown width, Triton assumed a mean W_w for all channels in the same category for that creek (i.e., side channel, cross-channel, blind channel, groundwater channel). Off-channel area was assumed to be valid fish habitat if it was observed to be wetted, connected, and had oxygen levels greater than 5 mg/L at the time of survey. Oxygen levels were assumed to be anoxic for fish below 2 mg/L and hypoxic below 5 mg/L. Extrapolation of wetted off-channel habitat east of the dike also assumed the correlation

between Anderson Creek and Kitimat River discharges was sufficient to apply the model equation of W_{At} as a function of Q_{Tt} . The W_A of all wetland habitat was also assumed to be constant between months and not dependent on Q_{Tt} (i.e., wetland area is considered to be a function of groundwater availability). Habitat suitability changes were based on DO, as the habitat potential for wetlands has been observed as oxygen limited.

5.2 Model Implications

Of the two estimation methods used to determine productivity, estimates of HU were more credible using HSI_{norm} compared to WUW in the approach. Triton maintains HSI_{norm} to be a more credible estimator because it ascribes higher importance to the individual areas (m^2) of hydraulic channel units measured in the field using Level-1 FHAPs. This is based on generally understood physical parameters that determine habitat suitability across specifically assigned hydraulic channel units. The WUW approach only considered the *total combined length* of component channel units in each stream, thus ignoring the *channel unit-specific width* data (and hence areal estimates) specific to each hydraulic channel unit observed. Use of the single WUW also assumed to be a constant, but representative value across all mapped channels of the same unit, thereby disregarding channel-specific widths. The result is not as informative of actual stream conditions, given that both length and width measurements had been taken at all channel units. Results for HU , determined using HSI_{norm} , also represent a more conservative estimate given the uncertainty in either approach. A decision to maintain the higher estimate in some cases, is in keeping with the precautionary principle and should serve as the basis for developing effective mitigation and offsetting measures.

5.3 Risk and Mitigation

Anderson Creek Fluvial Geomorphology

A degree of channel confinement will occur in the lower three reaches of Anderson Creek directly east of the Haul Road Bridge and west of the facility footprint. Anderson Creek's upstream-most reach moderately descends south off the alluvial fan and is quite braided with excellent cover, LWD, and extensive off-channel habitat that includes both ephemeral and perennial side channels. A high percentage of these channels will be lost by the Project due to the need to realign Beaver Creek and Anderson Creek upstream of the Haul Road Bridge. This will result in fewer channels downstream of the bridge. Surface flows in Anderson Creek will also no longer exit the stream atop the alluvial fan as cross-channel habitats in the area of interaction with Beaver Creek. Overall, this will lead to sustained increases in flow in a more confined mainstem channel, which may influence sediment transport and changes in substrate composition; however, any effect from the elevated discharges represent a net increase in the rate of sediment transport and deposition to lower gradient, downstream reaches that are tidally influenced. The tidal influence makes the reaches less suitable to spawning for resident freshwater salmonids including RB and DV, and possibly smaller anadromous species including PK; however, it may be suitable for CM.

It is difficult to predict consequences of the effects from the sustained increased flow in Anderson Creek without direct observations. A suitable monitoring program could ascertain whether the effect of habitat alteration over time, due to the sustained increase in discharge, is

likely to occur. Improved understanding represents an informative management approach in the mainstem of Anderson Creek that will be subject to confinement by the facility footprint. It could also be considered as a means to support Beaver Creek's mainstem channel realignment as an offsetting measure.

Creek Realignment

Due to the potential for flow obstruction of Beaver Creek upstream of the Project, the primary mitigation measure will be realignment of Beaver Creek's mainstem channel around the Project footprint. This would maintain Upper Beaver Creek connectivity to the estuary channels west of the mouth of the Kitimat River. Maintenance of connectivity also prevents additional PAD from occurring above the Project footprint, where CO spawning is known to occur; however, because of the input of Beaver Creek into Anderson Creek's mainstem channel, a portion of mainstem Anderson Creek will also likely have to be re-aligned in order to allow flows from both streams to continue unobstructed along the Lower Anderson Creek mainstem channel to the estuary. With effective channel realignments in Beaver Creek and Anderson Creek, Upper Beaver Creek will continue to support CO and other species of CRA importance.

The Beaver Creek realignment channel will likely provide additional pool and rearing habitat characteristics required to sustain the current level of CO production. Riparian habitat, instream vegetation, and overhanging vegetation also feature prominently in Beaver Creek and would be permitted within the realignment around the west side of the Project footprint, with consideration given to the necessary safety restrictions. Boulder complexity and artificial instream structures combined with natural scour processes after the structures are installed will also provide beneficial rearing habitat in the realigned sections of Beaver Creek and Anderson Creek.

Benthic production did not factor into the assessment of productivity; some understanding of food availability would be an informative measure. Prior to construction, Beaver Creek should also be re-examined to determine current levels of productivity and establish baseline comparisons with potential offsetting locations. It will also be necessary to examine Lower Beaver Creek and establish objective targets for benthic productivity as part of the offsetting planning.

Kitimat River Side Channel Realignment

The east side of the Project footprint will overlap with part of the KRSC system and realignment will be necessary to maintain flows into the unaffected portion of the oxbow channel. A little over 100 m separates the footprint from the west edge of *Kitimaat* Indian Reserve (IR) No. 1. This presents several options for enhancement, but determination of the most optimal relocation should be based on dialogue between LNG Canada and the Haisla. The oxbow channel is not well-oxygenated for at least part of the year, possibly due to the intermittent nature of the existing KRSC. Evidence suggests the oxbow portion of the KRSC system is tidally influenced and supports a potential for the area to act as a spawning habitat for EU. The Haisla currently conduct annual EU surveys in the oxbow channel (Jacobs, pers. comm.)

A realigned side channel should be designed to ensure perennial flow at all stages of stream discharge sufficient to maintain DO levels in the oxbow leading to a higher potential for EU

recovery, given historic observations. It is not known from the baseline investigation whether CO or CM currently spawn in the KRSC system; CM fry were observed in the north side channel of KRSC in March 2013. Potential development of additional spawning and rearing habitat for CO and CM seems possible, and should be investigated further. The Haisla Nation's input will also be critical for effective channel realignment. There may be an opportunity to create additional experimental side channels or enhance existing channels located on *Kitimaat* IR No. 1, which have previously been observed to support EU (FISS, 2013; Triton, 2014a).

Water Availability

LNG Canada plans to withdraw water from the lower Kitimat River for Project purposes. The 7Q10 and 7Q20 guidelines were developed to deal with basic dilution of domestic and industrial waste disposal in BC waters and deal with contamination risk during naturally occurring low flows. Water demand for cooling is logically driven by weather conditions, with higher demand expected in warm weather and lower demand in cool weather.

For summer, the main risk is to CM spawning in the lower Kitimat River; however, it is not well understood from this assessment whether this part of the river has important CM spawning habitat. Risk to spawners results from changes in water level during these months under natural flows. When the Project is in place it will also be driven by the natural recession of the hydrograph, but at a slightly lower base level. Fish that use the lower river will spawn at a lower water level in the fall. The drop in water level over winter will continue to be driven by the natural flow recession of the Kitimat River into the spring, but likely at a reduced demand, if there is less of a need for cooling in winter. LNG Canada will likely need to develop a plan for water management under the terms of its water licence. The water management plan should address seasonal needs for the Project and any implications to fish use in the Kitimat River, which may include a need for a detailed instream flow assessment.

The amended *Fisheries Act* states that resource development activities must not lead to *Serious Harm to Fish* that are part of CRA fisheries, which brings the discussion of risk to a focus on what proportion of the population (i.e., the fishery) in the Kitimat River actually spawns in the section of the river downstream of the intake. The proportion of individual spawners in the river section downstream the intake is expected to be relatively small and an incremental increase in risk to a small proportion of the population is not likely to have a significant effect on the fishery. For EU, a high percentage of the spawning population would utilize this river section, so any risk associated with Project activities in this section of the river is legitimate; however, at an incrementally reduced discharge, the upper tidal limit in the river would extend further upstream, thus assisting with the spawning migration, although this is expected to vary from year to year and location to location on the river. It is difficult to confidently detect whether a residual effect will on EU would occur without empirical evidence of observed spawning locations. Eulachon spawning in the Kitimat River has not occurred in sufficient numbers in recent years (Moody, 2008).

As a follow-up from the initial desktop evaluation by Stantec (2014a), Triton recommends a field inventory of side channel habitats and potentially vulnerable habitats along the river mainstem downstream of the intake to verify site-specific conditions and support the initial assessment of water availability. Improved understanding of fish use in the section of the Kitimat River will

allow for effective mitigation against both site-specific and population level risks, as in the case of Pacific salmon and EU, respectively.

5.4 Offsetting

Effects that cannot be avoided or fully mitigated will require an authorization from DFO to commit *Serious Harm to Fish* under Paragraph 35(2)(b) of the *Fisheries Act* (2012). The terms of the authorization will involve mandatory offsetting measures that must uphold the guiding principle of *No Net Loss* of productivity. Offsetting of fish habitat must include measures that address spatial and temporal losses associated with the Project's development timeline. If temporal losses are to be avoided, the implementation of offsets should commence early so that fish salvage and relocation efforts can be done in tandem with the onset of construction; otherwise, it is likely that DFO will request higher offset ratios above 1:1 in order to account for the temporal lag.

5.4.1 On-site Rehabilitation

The general approach taken in conceptualizing the offsetting measures is the development of similar habitats to those being lost due to the proposed development. Beaver Creek is the area where the highest degree of habitat loss is expected due to the Project. This area is thought to be an area of recruitment for juvenile fish flushed out into the Kitimat estuary during freshet as well as for rearing of juvenile salmonids from fish that spawn in either the upper reaches of Beaver Creek or the adjacent Anderson and Moore creeks. The proposed offsetting opportunities are generally located upstream from the site, with the exception of the re-alignment of both Beaver Creek and the Kitimat River side channel. Therefore, recruitment to the affected habitat as a component of overall productivity is not provided by those upstream offsets. To account for this, the offsetting plan should include both spawning and rearing habitats for salmonids in areas that would not be affected by the freshet to assist in achieving *No Net Loss* of productivity in the Kitimat system. A number of alternate options have been discussed.

5.4.1.1 Beaver Creek

The Project footprint lies directly over Beaver Creek, but the options for diverting the creek upstream of the Project site are limited. Consideration has been given for possible channel re-alignment west of the RTA rail line and the area of the proposed labour camp (i.e., workforce accommodation centre) and to the east of Haisla Boulevard.

The realignment of Beaver Creek will have a low gradient, similar to the existing stream alignment. Habitat features, such as pools deep enough to support overwintering and rearing of fish (approximately 1 m below average grade) along with boulder clusters and cobble features in the stream bed, would be constructed over the length between the northern edge of the Project and the Anderson Creek fan. Where there is room, wider sections that would imitate off-channel habitats could be included in the design. The construction of pools and complex cover habitat ensures suitable habitat in Beaver Creek can be maintained and enhanced to allow for additional overwintering and rearing habitat for juvenile salmonids.

5.4.1.2 Anderson Creek

The affected part of mainstem Anderson Creek has the potential to be developed as a partial offsetting measure that would support the realignment of Beaver Creek as the primary offset to the Project footprint. Monitoring spawner abundance of CO and other salmonids throughout the length of this channel over time, given the expected change in flow regime and possible change in substrate composition, will improve on the understanding of CO inputs and general fish production to the system. The working hypothesis of this assessment is that the current spawning capacity does not fully account for the high numbers of juvenile CO observed; however, a limited amount of data currently supports this view.

Upstream of the Anderson Creek Bridge on the Haul Road, the Beaver Creek realignment would divert to the east as far as possible before flowing into Anderson Creek above the mainstem confluence and west of the Haul Road. This could improve Beaver Creek's capacity for rearing and overwintering of numerous species, including potential resident salmonids (i.e., RB and DV). A section of Anderson Creek's mainstem channel could also be realigned to accommodate the added flow from Beaver Creek with habitat features (e.g., boulder clusters and cobble cross-channel weirs) to maintain channel complexity, despite taking a more direct path toward the estuary. It is recognized that LWD, a common stream complexing feature, may or may not be used along realigned sections of Anderson and Beaver creeks, depending on proximity to LNG infrastructure and safety requirements.

5.4.1.3 Kitimat River Side Channel

The east side of the Project footprint extends over part of an existing Kitimat River side channel. The realignment of the channel around the footprint is proposed to avoid loss of seasonal CO and CM rearing (and possible CM spawning) habitats in the channel. The realigned channel would be constructed to the east of the footprint but between the footprint and the western boundary of *Kitamaat* IR No. 1.

5.4.2 Off-site Compensation

Offsetting measures could also include the development of compensation channel networks elsewhere in the river system, such as in sites located further upstream along the Kitimat River side channel system and possibly along other main tributaries with increased stream gradients and perennial flows, such as Hirsch Creek. Construction of spawning and rearing channels, with suitable gradients, substrates, LWD cover, and off-channel habitat, would promote comparable spawning and rearing capabilities that can sufficiently offset the aquatic habitat in the Kitimat River side channel system, Anderson and Beaver creeks' side channels, and the groundwater channel system located in the northwest corner of the Project footprint where the construction camp has been proposed.

5.5 Adaptive Management

For the offsetting plan to successfully achieve the guiding principle of *No Net Loss* of productivity over the long term and under a federal *Fisheries Act* authorization, ongoing environmental management will be necessary. Ongoing environmental management iteratively reduces the uncertainty about the ways by which the development activity has influenced aquatic

habitats on the affected landscape. For LNG Canada, monitoring programs could be developed that directly test hypotheses about the factors that are most influential to the CRA fisheries put at risk by the Project; in this case the fisheries are EU and CO. Well thought-out adaptive management experiments are often predicated on an agreement to collaborate among interests (Walters and Holling, 1990; Walters, 1997) and could involve a concerted offsetting strategy that engages all interests and provides benefits that better reflect the values held by those interests.

The ecological implications of combined development activities in the RSA should not be treated in isolation, for it narrowly defines the problem and can lead to consequences that fail to confer clear benefits to multiple interests. A number of management options have been alluded to in this assessment, but two clear objectives remain from a local fisheries perspective: EU recovery for the Haisla Nation and Pacific salmon enhancement for DFO. Rehabilitation of the Kitimat River EU fishery is a worthy goal, and experimental management could involve multiple land interests under various forms of title along the traditional EU harvesting sites at *Kitamaat* IR No. 1, including RTA, DFO, LNG Canada, and KLNG. Areas of EU enhancement efforts would result in a positive ecological and social outcome when working in collaboration with the Haisla First Nation and the adjacent industry landowners.

6.0 Conclusion

Pacific salmon is one of Canada's most valuable fisheries; both wild and hatchery-reared salmon stocks hold high fisheries value for food, social, and ceremonial purposes. Grease rendered from EU by the Haisla Nation has historically been among the most valuable trade commodities to both Coastal and Interior First Nations of the province.

The Project is located directly adjacent to a considerable amount of previously disturbed coastal temperate estuary floodplain. Scientific evidence and local knowledge support the working hypothesis that the freshwater and estuary ecosystems in the Project Area, particularly the area of *Yaksda wa'wais*, represent potential surplus habitat for Pacific salmon in the Lower Kitimat River and are of particular importance to rearing and overwintering juvenile CO. This is likely to add benefit to existing DFO hatchery enhancement efforts directly upstream of the Project. Eulachon is ostensibly absent compared to historic abundances due to pre-existing unknown factors, but its recovery represents the single most important resource objective to the Haisla Nation from a fisheries perspective (Jacobs, pers. comm.).

The outcome of environmental management experiments is often counter-intuitive, despite a considerable amount of knowledge gained about the ecosystem (Walters, pers. comm.). Active adaptive management of these aquatic ecosystem represents a meaningful and informative means of environmental management for the Project, should it proceed over an as yet undetermined duration. There is considerable likelihood that, given the policy changes under revised environmental legislation, increased resource development activity is expected near the Kitimat estuary, thereby expanding the potential for cumulative effects. Predictions on the ecological consequences of combined activities can be spurious without a set of clearly defined environmental management goals and openly developed monitoring programs. Focused monitoring programs are the groundwork of experiments aimed at informing on and upholding fisheries values, while promoting resource development under a collaborative process for environmental management.

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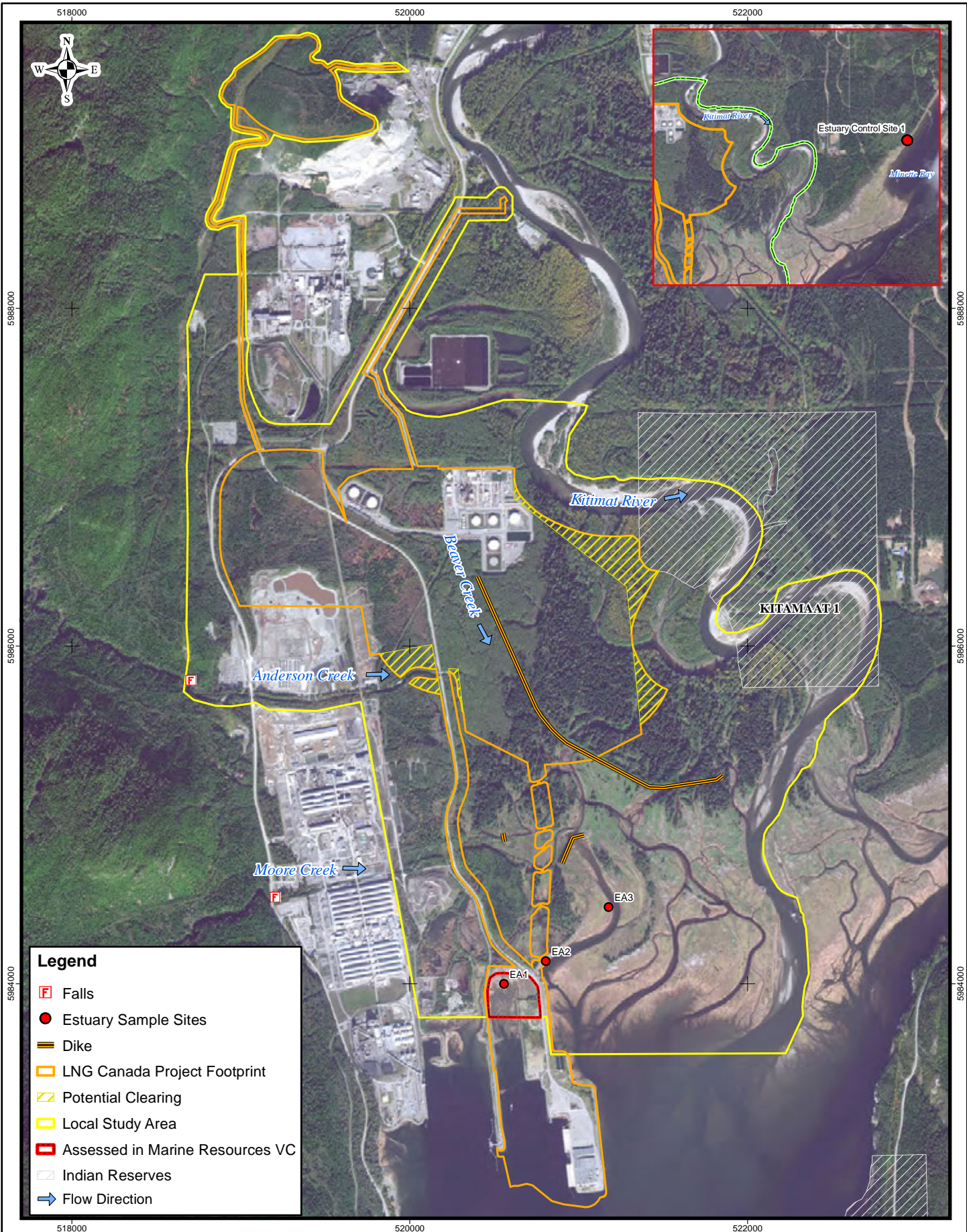
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APPENDIX F-1
LOCAL STUDY AREA OVERVIEW MAP



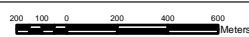
Legend

- F Falls
- Estuary Sample Sites
- Dike
- LNG Canada Project Footprint
- Potential Clearing
- Local Study Area
- Assessed in Marine Resources VC
- Indian Reserves
- Flow Direction



Basemap Source:

Orthophoto



Scale: 1:30,000

Map Datum:

UTM NAD 83 Zone 9

Appendix F-1 - Local Study Area Overview Map

Project No:

6018

File No:

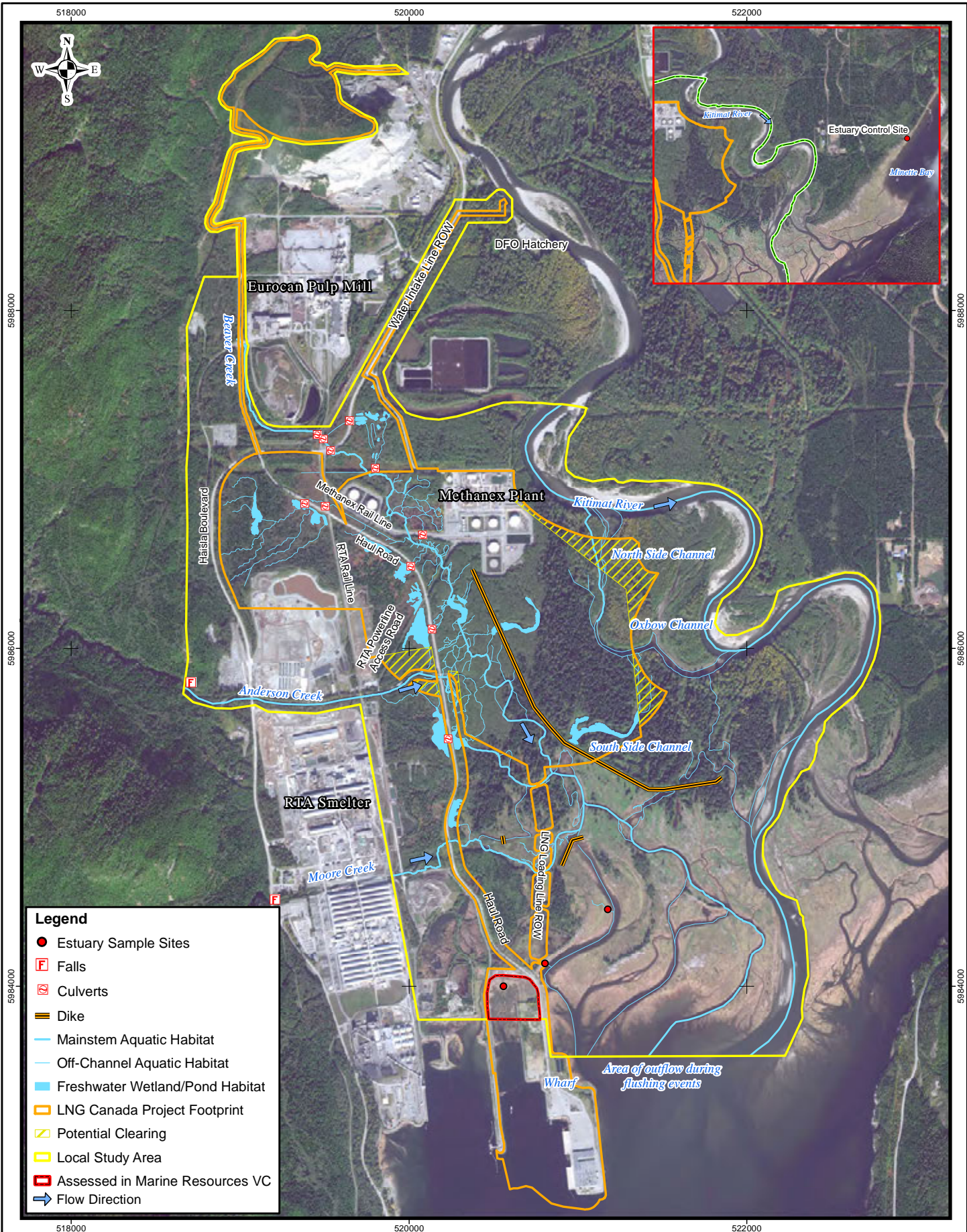
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Date:

Aug 25, 2014

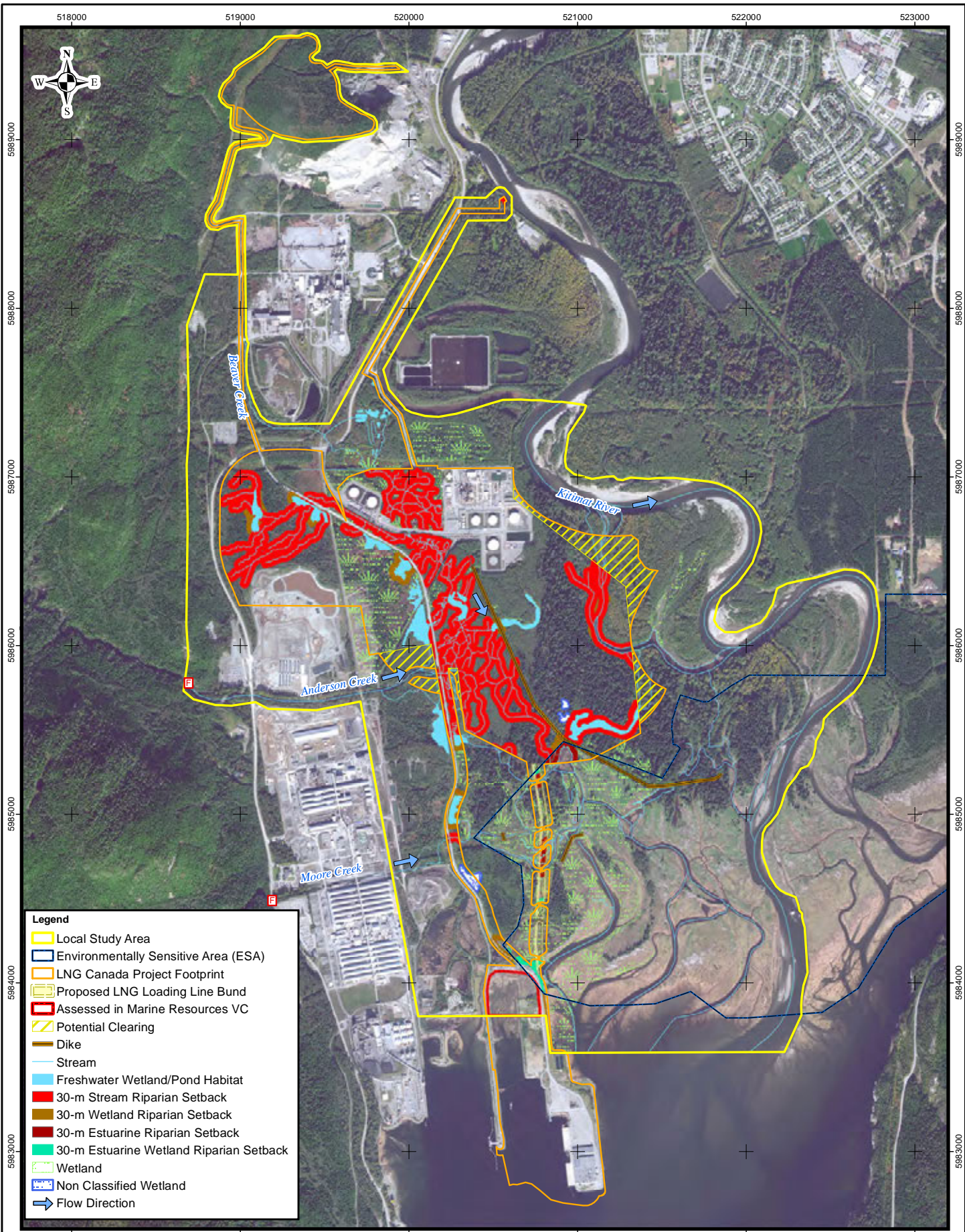


APPENDIX F-2
LANDSCAPE AND WETTED HABITAT

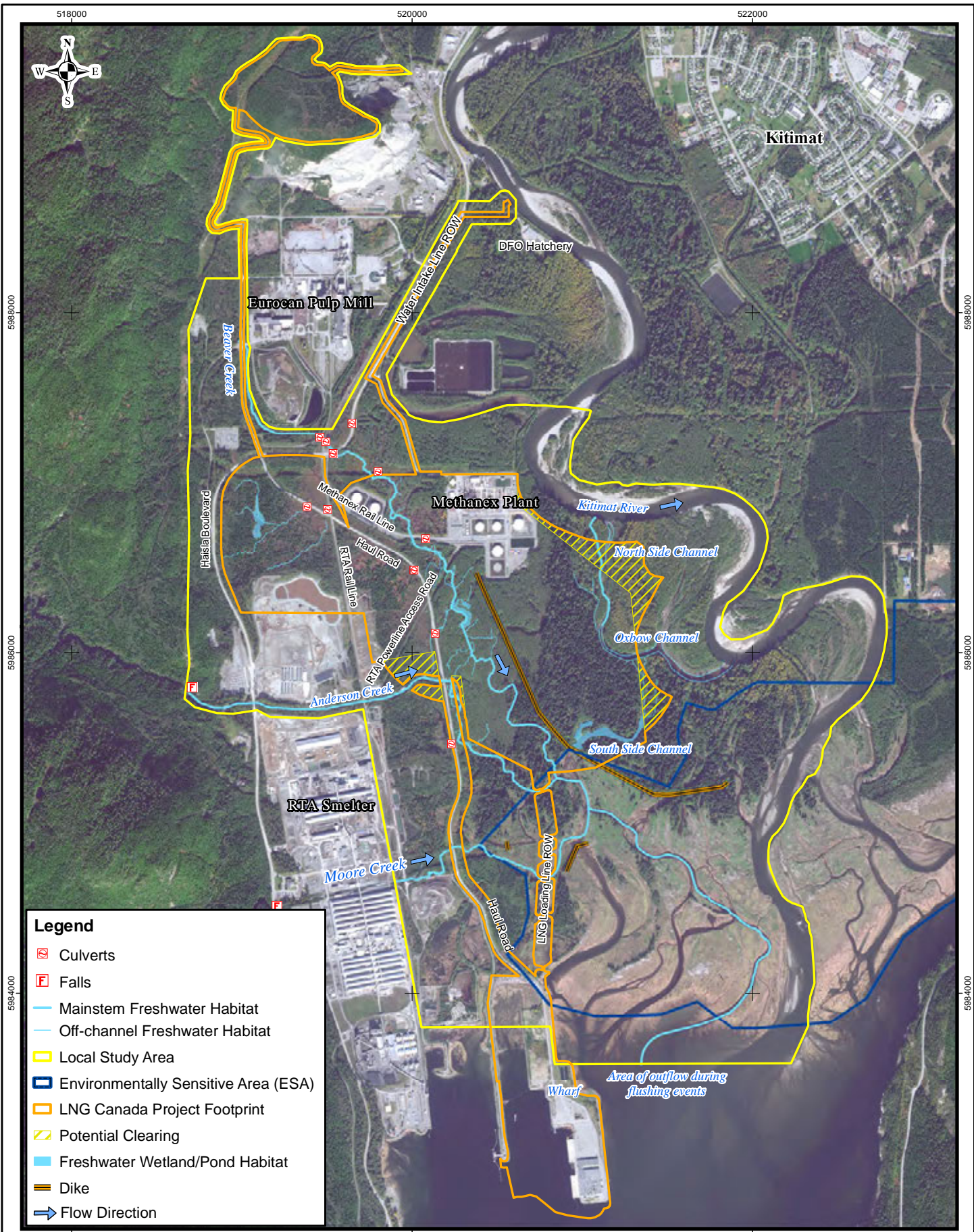


- Legend**
- Estuary Sample Sites
 - F Falls
 - ☐ Culverts
 - ▬ Dike
 - Mainstem Aquatic Habitat
 - Off-Channel Aquatic Habitat
 - Freshwater Wetland/Pond Habitat
 - ▭ LNG Canada Project Footprint
 - ▨ Potential Clearing
 - ▭ Local Study Area
 - ▭ Assessed in Marine Resources VC
 - ➔ Flow Direction







APPENDIX F-3
AFFECTED RIPARIAN HABITAT



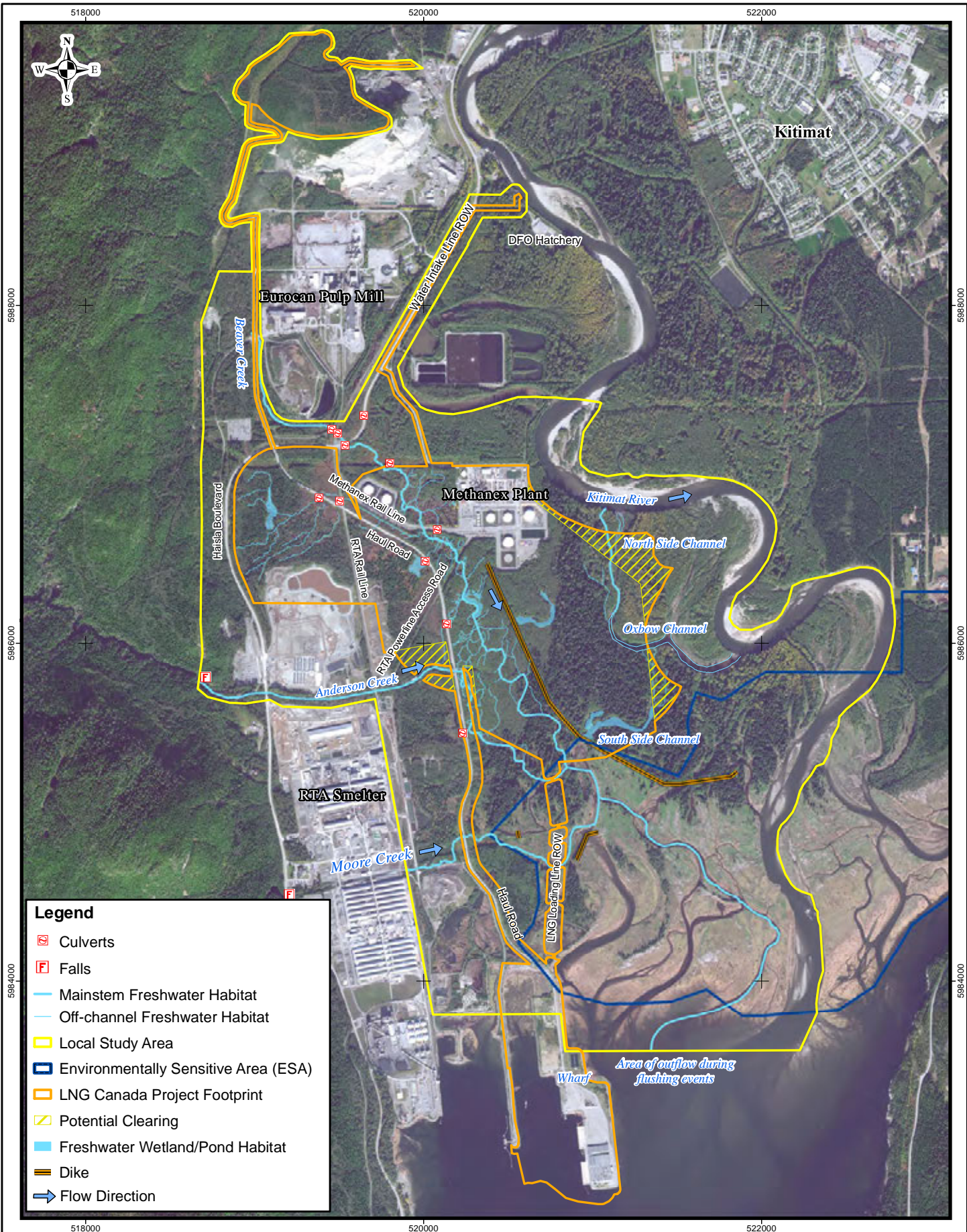
APPENDIX F-4A
AFFECTED FRESHWATER OFF-CHANNEL HABITAT AT Q_{MIN}



Legend

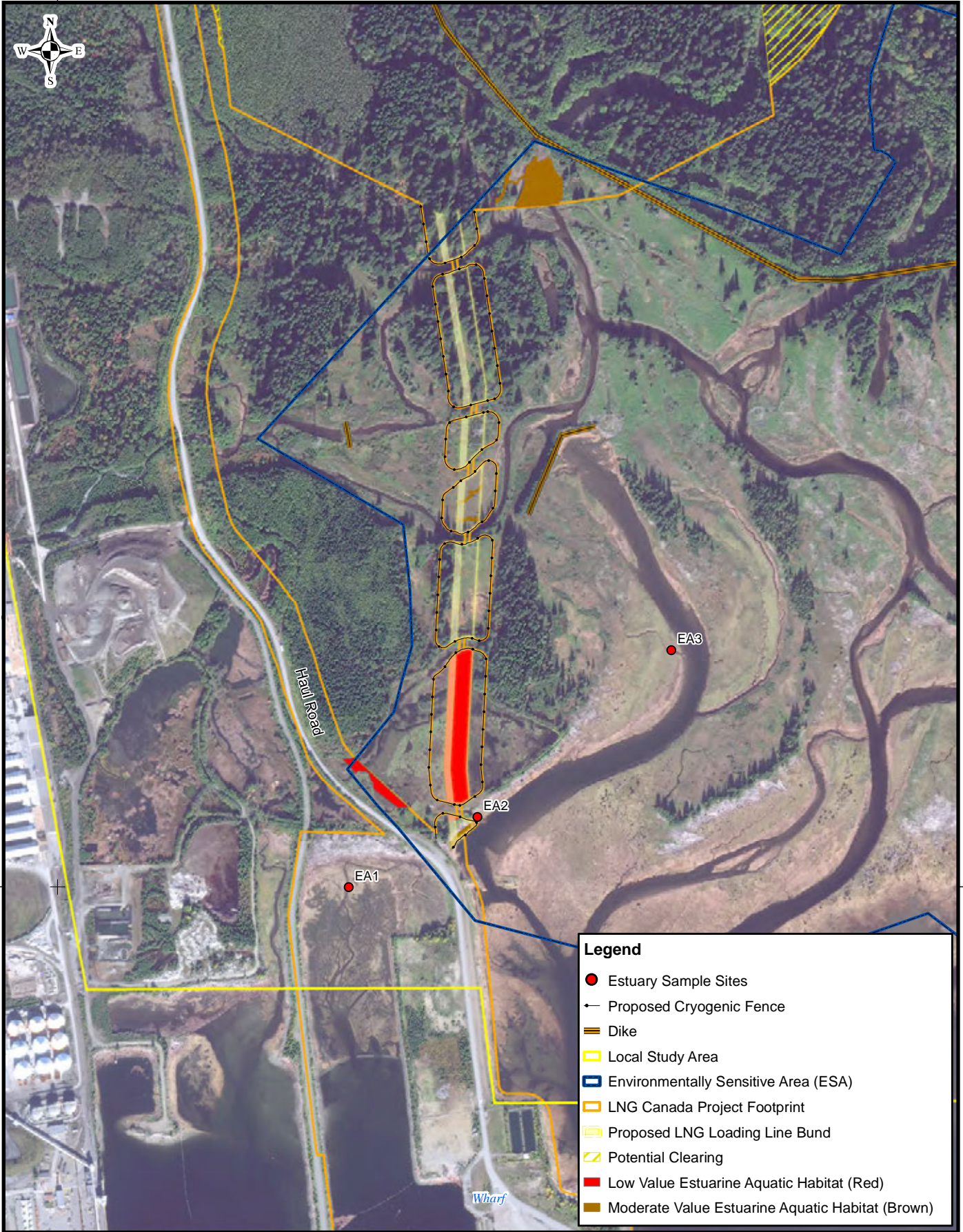
-  Culverts
-  Falls
-  Mainstem Freshwater Habitat
-  Off-channel Freshwater Habitat
-  Local Study Area
-  Environmentally Sensitive Area (ESA)
-  LNG Canada Project Footprint
-  Potential Clearing
-  Freshwater Wetland/Pond Habitat
-  Dike
-  Flow Direction

APPENDIX F-4B
AFFECTED FRESHWATER OFF-CHANNEL HABITAT AT Q_{MAX}



APPENDIX F-5
AFFECTED ESTUARINE HABITAT

520000



Legend

- Estuary Sample Sites
- ← Proposed Cryogenic Fence
- ▬ Dike
- ▭ Local Study Area
- ▭ Environmentally Sensitive Area (ESA)
- ▭ LNG Canada Project Footprint
- ▭ Proposed LNG Loading Line Bund
- ▭ Potential Clearing
- Low Value Estuarine Aquatic Habitat (Red)
- Moderate Value Estuarine Aquatic Habitat (Brown)

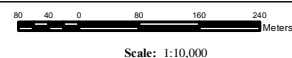
5984000

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Basemap Source:
Orthophoto



Map Datum:
UTM NAD 83 Zone 9

Appendix F-5 – Affected Estuarine Habitat

Project No:
6018

File No:
Map#: N:\ACTIVE\6018_Kitimat_Creeks\MXD\LSAOverview.mxd

Date:
Aug 27, 2014



APPENDIX F-6

NORMALIZED HABITAT SUITABILITY INDEX HSI_{norm} SUMMARY

Species	Stage	Unit	Anderson Creek			Beaver Creek			Moore Creek			Kitimat River Side Channel		
			n	mean	σ	n	mean	σ	n	mean	σ	n	mean	σ
CO	Adult	P	10	0.34	0.32	4	0.24	0.44	1	0.00	-	1	0.00	-
		RF	27	0.57	0.30	14	0.40	0.28	2	0.25	0.32	1	0.00	-
		RN	-	-	-	2	0.96	0.06	3	0.58	0.52	1	0.00	-
	Fry/Parr	P	10	0.35	0.26	4	0.34	0.44	1	0.99	-	1	0.86	-
		RF	27	0.43	0.33	14	0.60	0.36	2	0.34	0.29	1	0.42	-
		RN	-	-	-	2	0.00	0.00	3	0.70	0.26	1	0.56	-
RB	Adult	P	10	0.35	0.32	4	0.22	0.26	1	0.00	-	1	0.00	-
		RF	27	0.49	0.34	14	0.27	0.21	2	0.32	0.39	1	0.00	-
		RN	-	-	-	2	0.18	0.06	3	0.41	0.49	1	0.00	-
	Fry	P	10	0.34	0.22	4	0.28	0.22	1	0.10	-	1	0.18	-
		RF	27	0.26	0.16	14	0.49	0.28	2	0.65	0.49	1	0.73	-
		RN	-	-	-	2	0.03	0.04	3	0.36	0.13	1	0.83	-
	Parr	P	10	0.51	0.26	4	0.42	0.42	1	0.00	-	1	0.00	-
		RF	27	0.67	0.25	14	0.60	0.22	2	0.47	0.15	1	0.06	-
		RN	-	-	-	2	0.00	0.00	3	0.69	0.52	1	0.13	-
CM	Adult	P	9	0.23	0.25	4	0.02	0.03	1	0.00	-	1	0.00	-
		RF	28	0.24	0.27	13	0.08	0.19	2	0.11	0.16	1	0.00	-
		RN	-	-	-	2	0.00	0.00	3	0.04	0.06	1	0.00	-
PK	Adult	P	6	0.07	0.08	3	0.05	0.07	1	0.00	-	-	-	-
		RF	20	0.22	0.18	8	0.13	0.10	2	0.13	0.18	-	-	-
		RN	10	0.34	0.32	4	0.24	0.44	3	0.17	0.14	-	-	-

Note: P = pool, R = riffle, RN = run

APPENDIX F-7

WEIGHTED USABLE WIDTH *WUW* (METRES) SUMMARY

Species	Stage	Unit	Anderson Creek			Beaver Creek			Moore Creek			Kitimat River Side Channel		
			<i>n</i>	<i>mean</i>	σ	<i>n</i>	<i>mean</i>	σ	<i>n</i>	<i>Mean</i>	σ	<i>n</i>	<i>Mean</i>	σ
CO	Adult	P	-	-	-	2	0.00	0.00	1	0.00	-	1	0.00	-
		RF	10	4.43	4.49	4	1.52	2.81	2	1.60	2.14	1	0.00	-
		RN	27	9.37	6.00	15	3.21	2.28	3	5.95	5.16	1	0.01	-
	Fry/Parr	P	-	-	-	2	7.83	4.41	1	9.75	-	1	13.83	-
		RF	10	4.79	3.55	4	2.33	3.70	2	1.67	1.09	1	0.61	-
		RN	27	6.12	5.02	15	4.78	2.78	3	6.00	1.65	1	1.29	-
RB	Adult	P	-	-	-	2	0.00	0.00	1	0.00	-	1	0.00	-
		RF	10	4.55	4.63	4	1.27	1.73	2	2.05	2.62	1	0.00	-
		RN	27	8.09	6.31	15	2.34	2.29	3	3.68	3.91	1	0.01	-
	Fry	P	-	-	-	2	1.32	0.45	1	0.99	-	1	2.96	-
		RF	10	4.76	3.79	4	1.50	1.52	2	3.73	2.44	1	1.06	-
		RN	27	3.68	1.95	15	3.84	2.33	3	3.08	0.86	1	1.91	-
	Parr	P	-	-	-	2	0.32	0.45	1	0.00	-	1	0.00	-
		RF	10	6.99	5.06	4	2.84	3.80	2	2.69	1.50	1	0.09	-
		RN	27	11.02	5.92	15	5.18	2.37	3	7.56	6.04	1	0.29	-
CM	Adult	P	-	-	-	2	0.00	0.00	1	0.00	-	1	0.00	-
		RF	9	3.07	3.96	4	0.08	0.11	2	0.73	1.03	1	0.00	-
		RN	28	3.88	4.63	13	0.89	2.22	3	0.32	0.51	1	0.00	-
PK	Adult	P	-	-	-	2	0.02	0.02	1	0.00	-	-	-	-
		RF	6	0.63	0.52	3	0.33	0.47	2	0.85	1.20	-	-	-
		RN	20	3.20	2.10	8	1.11	0.91	3	1.63	1.47	-	-	-

Note: P = pool, R = riffle, RN = run

APPENDIX F-8

OFF-CHANNEL WETTED AREA W_A (SQUARE METRES) SUMMARY

Beaver Creek			Anderson Creek			Kitimat River Side Channel		
Channel ID	May	Sept	Channel ID	May	Sept	Channel ID	May	Sept
Wetland Habitat								
WL1	7,896	7,896	-	-	-	WL8	16,211	16,211
WL2	231	231	-	-	-	-	-	-
WL6	6,274	6,274	-	-	-	-	-	-
Total Area (m²)	14,401	14,401					16,211	16,211
Cross-channel Habitat								
-	-	-	CC-C1A	79	-	-	-	-
-	-	-	CC-C1B	40	48	-	-	-
-	-	-	CC-C1C	106	129	-	-	-
-	-	-	CC-C1D	25	45	-	-	-
-	-	-	CC-C1E	3,204	1,402	-	-	-
-	-	-	CC-C1F	135	207	-	-	-
-	-	-	CC-C1G	174	174	-	-	-
-	-	-	CC-C1H	60	238	-	-	-
-	-	-	CC-C1I	41	93	-	-	-
-	-	-	CC-C1J	65	79	-	-	-
-	-	-	CC-C2A	812	638	-	-	-
-	-	-	CC-C2B	817	528	-	-	-
-	-	-	CC-C2C	266	-	-	-	-
-	-	-	CC-C2D	280	-	-	-	-
-	-	-	CC-C2E	146	-	-	-	-
Total Area (m²)				6,250	3581			
Side Channel Habitat								
SC-C1	136	114	SC-C17	270	296	SC-C32	317	317
SC-C2	320	320	SC-C18	420	239	SC-C33	295	295
SC-C3	330	330	SC-C19	180	197	-	-	-
SC-C4	392	327	SC-C20	41	77	-	-	-
SC-C5	276	276	SC-C21	124	105	-	-	-
SC-C6	585	585	SC-C22	29	33	-	-	-
SC-C7a	245	207	SC-C23	56	114	-	-	-
SC-C7b	70	70	SC-C24	345	221	-	-	-
SC-C7c	24	40	SC-C25	88	-	-	-	-
SC-C7d	19	73	SC-C26	62	68	-	-	-
SC-C8	361	361	SC-C27	168	123	-	-	-
SC-C9	225	225	SC-C28	152	162	-	-	-
SC-C10	225	225	SC-C29	405		-	-	-

Beaver Creek			Anderson Creek			Kitimat River Side Channel		
Channel ID	May	Sept	Channel ID	May	Sept	Channel ID	May	Sept
SC-C11	1,610	1,075	SC-C30A	401	-	-	-	-
SC-C12	740	740	SC-C30B	191	-	-	-	-
SC-C13	548	-	-	-	-	-	-	-
SC-C14	544	-	-	-	-	-	-	-
SC-C15	711	-	-	-	-	-	-	-
SC-C16	278	-	-	-	-	-	-	-
Total Area (m²)	7,639	4,968		2,932	1,635		612	612
Back Channel Habitat								
GW-C1a	1,306	1,306	BC-C42A	237	-	BC-C48	630	-
GW-C1b	561	-	BC-C42B	67	-	BC-C49	207	209
GW-C1c	485	485	BC-C42C	39	-	BC-C50	1,039	1,039
GW-C1d	1,808	1,808	BC-C42D	74	-	BC-C51	472	-
GW-C1e	811	-	BC-C42G	243	-	BC-C52	266	-
GW-C1f	507	-	-	-	-	BC-C53	320	-
GW-C1g	1,887	-	-	-	-	-	-	-
GW-C1h	301	-	-	-	-	-	-	-
GW-C1i	1,323	1,323	-	-	-	-	-	-
GW-C1j	768	-	-	-	-	-	-	-
GW-C1k	340	-	-	-	-	-	-	-
GW-C1l	51	-	-	-	-	-	-	-
GW-C1m	43	-	-	-	-	-	-	-
GW-C1n	56	-	-	-	-	-	-	-
GW-C3	1,000	-	-	-	-	-	-	-
GW-C4	240	240	-	-	-	-	-	-
BC-C1a	357	-	-	-	-	-	-	-
BC-C1b	281	281	-	-	-	-	-	-
BC-C1d	152	102	-	-	-	-	-	-
BC-C1e	140	-	-	-	-	-	-	-
BC-C1f	263	-	-	-	-	-	-	-
BC-C1j	156	156	-	-	-	-	-	-
BC-C1k	265	265	-	-	-	-	-	-
BC-C1m	143	-	-	-	-	-	-	-
BC-C2	191	191	-	-	-	-	-	-
BC-C3	32	54	-	-	-	-	-	-
BC-C4	54	69	-	-	-	-	-	-
BC-C5	22	31	-	-	-	-	-	-
BC-C6	58	-	-	-	-	-	-	-
BC-C7	34	-	-	-	-	-	-	-
BC-C8a	60	-	-	-	-	-	-	-

Beaver Creek			Anderson Creek			Kitimat River Side Channel		
Channel ID	May	Sept	Channel ID	May	Sept	Channel ID	May	Sept
BC-C8b	23	-	-	-	-	-	-	-
BC-C9	61	-	-	-	-	-	-	-
BC-C10	100	-	-	-	-	-	-	-
BC-C12	51	-	-	-	-	-	-	-
BC-C13	13	-	-	-	-	-	-	-
BC-C14	107	-	-	-	-	-	-	-
BC-C15	28	-	-	-	-	-	-	-
BC-C16	476	-	-	-	-	-	-	-
BC-C17	231	-	-	-	-	-	-	-
BC-C19	441	441	-	-	-	-	-	-
BC-C20	462	-	-	-	-	-	-	-
BC-C21	187	-	-	-	-	-	-	-
BC-C22	400	400	-	-	-	-	-	-
BC-C23	459	-	-	-	-	-	-	-
BC-C24	23	-	-	-	-	-	-	-
BC-C25	145	-	-	-	-	-	-	-
BC-C26	316	316	-	-	-	-	-	-
BC-C27	808	-	-	-	-	-	-	-
BC-C28	298	-	-	-	-	-	-	-
BC-C29	82	-	-	-	-	-	-	-
BC-C30	166	166	-	-	-	-	-	-
BC-C31	199	-	-	-	-	-	-	-
BC-C32	240	240	-	-	-	-	-	-
BC-C33	232	-	-	-	-	-	-	-
BC-C34	247	-	-	-	-	-	-	-
BC-C35	306	-	-	-	-	-	-	-
BC-C36	105	-	-	-	-	-	-	-
BC-C37	298	-	-	-	-	-	-	-
BC-C38	133	-	-	-	-	-	-	-
BC-C39	60	-	-	-	-	-	-	-
BC-C40A	272	-	-	-	-	-	-	-
BC-C40B	77	-	-	-	-	-	-	-
Total Area (m²)	20,741	7,874		660	-		2,934	1,248

Note: SC = side channel habitat, BC = blind channel/slough habitat, GW = groundwater-fed channel habitat